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MEDICAL SURVEILLANCE GUIDE (GUIDE FOR JOB-RELATED EXAMINATIONS)--ETC(U)
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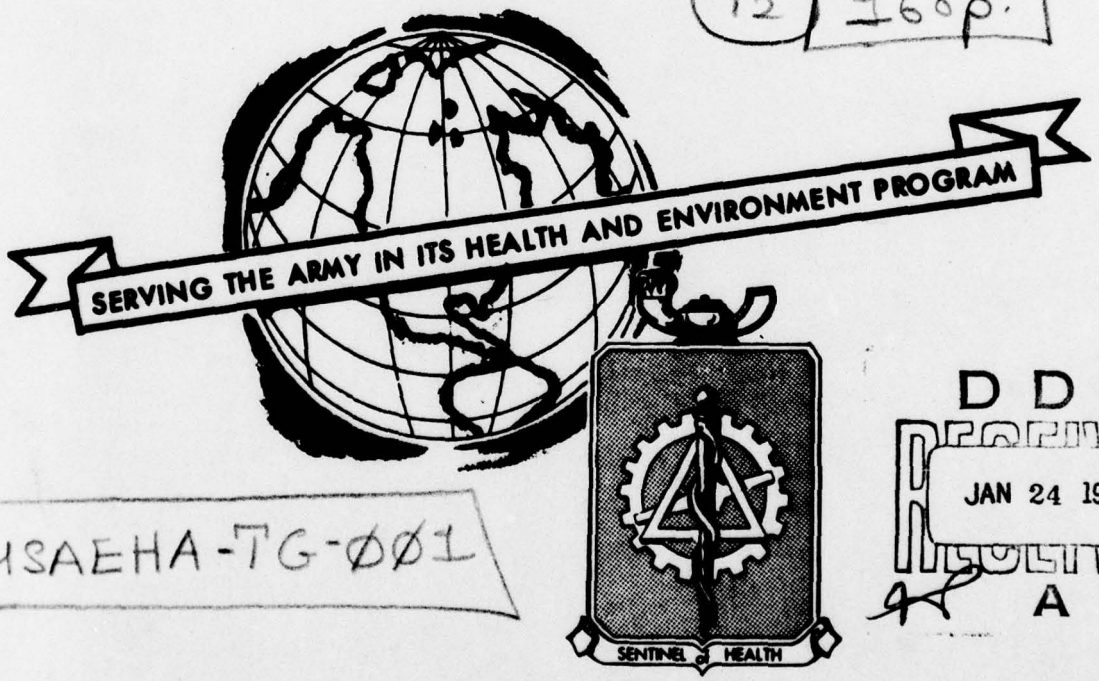

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ENVIRONMENTAL HYGIENE AGENCY
ABERDEEN PROVING GROUND, MD 21010

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DEPARTMENT OF THE ARMY
U. S. ARMY ENVIRONMENTAL HYGIENE AGENCY
ABERDEEN PROVING GROUND, MARYLAND 21010

HSE-OO/WP Technical Guide (Med) January 1975

PREFACE

This guide has been extensively revised and many additional substances have been included. Because of the large number of changes and additions, the guide has been reprinted in its entirety. Future changes or additions will be made as described in the foreword. Copies of the first printing should be considered obsolete and discarded.

On 9 October 1974, the Department of Labor issued Part 1960 of Title 29 of the Code of Federal Regulations (CFR) in the Federal Register, Volume 39, Number 197. This part, entitled Safety and Health Provisions for Federal Employees, requires each Federal agency to develop standards that are consistent with those of the Occupational Safety and Health Administration. AR 40-5, paragraph 4-2a, requires that health standards for the US Army will conform with 29 CFR 1910 unless otherwise established in Army directives. The medical surveillance recommended by this guide is consistent with standards of 29 CFR 1910 and with currently proposed standards. For exposures where no current or proposed standards exist, the recommendations are felt to be consistent with the current state of the art and sound medical practice.

It should be noted that the medical surveillance requirements recommended in this guide apply to active duty military personnel as well as Department of Army civilian employees.

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FOREWORD

This guide has been developed for inclusion in a standard three-ring binder to facilitate insertion of changes or new additions which will be published as the need arises. Suggested modifications to the guide are solicited and should be sent directly to this Agency, ATTN: Occupational Medicine Division. Whenever changes or additions are published, they will be mailed directly to those individuals or offices that have completed the attached sheet and returned it to this Agency or have requested receipt of this guide by separate correspondence. Please advise if you no longer wish to be on the mailing list or if your address has changed from that originally submitted.

MEDICAL SURVEILLANCE GUIDE

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To receive changes to the Medical Surveillance Guide, return this sheet to:

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U. S. ARMY ENVIRONMENTAL HYGIENE AGENCY
ABERDEEN PROVING GROUND, MARYLAND 21010

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MEDICAL SURVEILLANCE GUIDE*
(GUIDE FOR JOB-RELATED EXAMINATIONS)

CHAPTER 1. GENERAL

1. GENERAL. The recommendations presented herein contain guidelines for performing medical examinations on workers engaged in potentially health hazardous occupations. These guidelines are intended primarily to aid the occupational health physician and his staff in the development of an effective program of medical surveillance. Preplacement and periodic examinations will form the core of the surveillance program but it should be remembered that an examination in and of itself is of no benefit to the worker. Specific action, if indicated, must be taken with respect to the results. Depending on the nature of the medical findings, the actions might include modification of work conditions or habits, or transfer of an individual worker to another job. It is recognized that many physicians are unfamiliar with industrial operations and problems, therefore, job site visits to observe potential problem areas should be made by the physician accompanied by the safety officer, or ideally with an industrial hygienist. Often, an additional survey by a consultant industrial hygienist may be necessary to fully identify the extent of the potential health hazards. The information in this guide can then be adapted to a program which will provide maximum benefit for the continuing monitoring of employees' health.

2. RATIONALE FOR EXAMINATIONS. There are three primary reasons for performing job-related examinations:

a. To determine whether or not a worker is physically and mentally able to perform his job without undue risk of harm to himself or others.

b. To monitor the effects of the worker's exposure to specific biological, physical or chemical agents.

c. To detect early or subclinical effects resulting from accidental or inadvertent exposure to potentially hazardous agents.

3. JOBS REQUIRING PHYSICAL FITNESS.

a. Examination of a worker to determine his physical fitness to perform a given job is probably the most common type of job-related examination. Strict standards of physical fitness should be applied to persons upon whose performance may depend the life or health of others. For workers in this

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* Supersedes Medical Surveillance Guide, January 1974.

category such as lifeguards, firefighters, police officers, and overhead crane operators, complete age-related physical examinations should be mandatory, and a requirement for such examinations should be written into the employee's job description at the time of hire [Federal Personnel Manual (FPM) 339, Civil Service Handbook X-118].

b. Many other workers perform jobs requiring either keen senses or unusually strenuous activity, and while the job may involve little or no risk to others, a worker in poor physical condition may be a hazard to himself. Manual laborers, operators of moving equipment (forges, presses), workers performing operations in high places such as on scaffolds, and workers exposed to extremes of temperature should be in good physical condition. Periodic physical examinations are indicated for these workers at varying intervals dependent upon their age and health status. For example, older workers should be examined annually while younger workers, in general, need be examined only every 2 to 3 years. The standards of physical fitness required to remain on the job in the majority of these occupations are generally not as stringent as for those workers upon whose performance may depend the health of others. In fact, many workers with significant handicaps may be able to perform many jobs quite satisfactorily. It is therefore the responsibility of the examining physician to be familiar enough with the physical demands of the employees' work (SF 78, Certificate of Medical Examination) so that a fair judgment can be made to determine when a deteriorating physical condition warrants transfer to a less demanding job.

4. MAN AS A BIOLOGICAL INDICATOR. For a limited number of chemical exposures, the chemical or its metabolite can be measured in the blood or urine of the exposed worker. The level obtained in the blood or urine can then be correlated with the atmospheric level that existed at the work station. When available, these tests can be performed periodically as a check on the quality and use of engineering controls, personal protective equipment, and can be valuable in deciding whether or not the employee was overexposed. Unfortunately, this type of surveillance is limited to a relatively small number of chemical exposures which can be measured directly in body fluids such as lead in blood, mercury in urine, and to those which are metabolized to substances that can be measured such as the conversion of benzene to phenol which can be measured in the urine.

5. EARLY DETECTION OF CHRONIC EFFECTS.

a. One of the purposes of job-related examinations is to detect the ill effects of exposure at the earliest possible time. Subclinical or early clinical effects of exposure may be discovered by medical history, physical examination, or by special studies such as laboratory and x-ray examinations. Special studies may be particularly useful in detecting subclinical effects before overt disease is manifest. Medical history and physical examination may be useful in identifying early and mild symptoms or signs of an exposure

and require that the examiner be very astute in determining which are related to a possible work exposure, and which are due to nonoccupational medical problems. For example, exposure to the solvent, xylene, may cause fatigue, dizziness, and insomnia. In an individual worker, these symptoms, per se, are not pathognomonic, however, if several workers from the same area have these complaints, it may very likely be due to an occupational exposure.

b. A series of medical history questions can play a useful role in medical surveillance. Whether the questions are to be asked by the physician or nurse, or are printed as a questionnaire, they should be carefully selected at the local level to reflect the potential exposures of each type of job. As an example, explosive workers may be exposed to any or all of the following: nitroglycerine, lead, benzene, ethyl alcohol, acetone, and ethyl ether among others. Questions should include: whether the employee has headaches, especially if they were throbbing and worse on Mondays (nitroglycerine); whether he has felt weak or is easily fatigued (benzene or lead); whether he has felt dizzy, intoxicated or "high" at work (benzene, ethyl alcohol, ethyl ether, acetone); and whether he has noticed constipation, nausea, stomach cramps, or weight loss (lead). In order to develop a series of questions for each major job category, the occupational health staff must learn the potential exposures of each worker group. This guide lists the early symptoms of many exposures and may be helpful in developing questions. It is further recommended that the physician read about each type of exposure in a text book on occupational medicine to give him a better understanding of what questions would be most appropriate.

6. ESTABLISHING A PROGRAM.

a. There are two essential prerequisites to a sound medical surveillance program. First, the occupational health service must be aware of all workers required to meet specified levels of physical fitness in order for them to safely perform their duties. Second, all potential exposures warranting medical surveillance must be known to the health service. As required by AR 40-5, an inventory should be established and maintained listing all toxic or radioactive materials present on the installation, including information on how they are used and in what quantity. Additionally, a listing of all personnel working in health hazardous operations must be compiled, including such problem areas as noise, radiation, laser emissions, microwave radiation, biological exposures, chemical exposures, etc. The occupational health physician should visit all potentially hazardous operations to obtain first-hand information as to the extent of the health hazards and the desirability of medical surveillance. When the staff of the local installation is unable to make an adequate assessment of an operation, evaluation may be requested from the appropriate USAEHA Regional Division. Requests for these services should be forwarded through channels to the Chief of the respective USAEHA Regional Division.

b. Operations which are performed infrequently or for short periods of a work day cannot be effectively monitored by medical surveillance. An example of this situation would be a worker melting lead for a few minutes of the day every 3 or 4 months. Although the exposure might be high during these few minutes, the total amount of lead absorbed would be small, and examination of the worker's blood for lead would show only normal levels.

7. PREPLACEMENT EXAMINATIONS.

a. General. Preplacement examinations are an essential phase of medical surveillance. Any worker entering a potentially hazardous job should have a careful and complete history and physical examination to insure that his health status will allow him to safely perform his duties. In addition, for any job in which regular medical surveillance is planned, base line data should be obtained which will help in evaluating future medical screening. For example, base line audiograms should be obtained for personnel entering potentially noise hazardous occupations, and cholinesterase levels should be obtained for personnel who will be using organophosphate compounds.

b. Detection of Hypersusceptible Workers. Preplacement screening for hypersusceptible workers is now possible for selected types of exposure. This type of screening should be included in a medical surveillance program.

(1) Hereditary Antitrypsin Deficiency. Some cases of pulmonary emphysema have been shown to be related to a genetic defect: lack of an alpha-1-globulin called alpha-1-antitrypsin. Persons who are deficient in this serum protein are highly prone to develop emphysema. Exposure to normally "safe" levels of dusts or irritant chemicals may lead to emphysema in these persons. All employees who may be exposed to dust or to respiratory irritants should have a screening test for this deficiency as part of their preplacement examinations. Any person who has a deficiency in alpha-1-antitrypsin should not be employed in any job that would increase his risk of emphysema.

(2) Glucose-6-phosphate dehydrogenase (G-6-PD) Deficiency. There are several chemicals used in the Army that are capable of producing hemolytic anemia in susceptible individuals. These persons have a deficiency of the enzyme G-6-PD. The following is a list of exposures which may cause hemolytic anemia in such susceptible individuals: arsenic trioxide dust, benzene vapor, lead paint or fumes, methyl cellosolve vapor, phosphorus dust or mist, trinitrotoluene (TNT) dust or mist, and environments with an elevated partial pressure of oxygen. There are three tests available to detect susceptible workers. One of these tests should be required as part of the preplacement examination: assay for G-6-PD, glutathione instability, and methemoglobin reduction test. Workers with a deficiency of G-6-PD should not be employed where they may be exposed to any of the above chemicals. This defect shows considerable racial variation: Kurdish Jews 60%, Persian and

Iraqi Jews 25%, Sardinians 13%, American Negroes 12%, Filipinos 12%, East Indians 11%, Chinese 5%, Arabs 3%, European Jews 0.2%, and Caucasians 0.1%. On a cost-benefit basis, it is probably not worthwhile to include the latter two groups in a G-6-PD screening program.

(3) In addition to the above-mentioned enzyme deficiency states, there are a large number of disease states that are adversely affected by certain occupational exposures. Where pertinent, these are mentioned in the medical surveillance section of the specific compounds. However, it is not the intent of this guidance to cause the removal of any worker currently employed in such a situation without appropriate medical evaluation.

8. SPECIFIC EXPOSURES.

a. Noise. All personnel working in a potentially noise hazardous area (see TB MED 251 - Noise and Conservation of Hearing) should receive a preplacement audiogram and periodic screening audiograms at least annually thereafter. Further medical surveillance is not necessary unless indicated by another aspect of the employee's work.

b. Temperature Extremes. (Heat and Cold, TB MED's 175 and 81). All personnel exposed to a hot or cold environment should have a careful preplacement examination. Persons with obesity, hyperthyroidism, or cardiovascular or chronic respiratory problems should be carefully evaluated prior to employment in a hot environment. Persons with hypothyroidism and peripheral vascular disease should be employed in cold areas only with great caution. In general, periodic medical examinations are not of specific value in evaluating exposure to temperature extremes. Considerations for periodic examinations should be based on the rigors of the job and the age and health of the individual worker. Examinations should emphasize general physical fitness and cardio-pulmonary status.

c. Biological Hazards. Within the Army, except for special instances, periodic screening is necessary only for personnel exposed to tuberculous patients or animals. All such occupationally exposed persons, both military and civilian, will have a tuberculin skin test semiannually if not known previously to be tuberculin positive, or an x-ray examination of the chest if a previous tuberculin test was positive, when initially assigned to such duties and every 6 months thereafter as long as exposure continues. It is desirable to perform a tuberculin skin test on nonreactors 2 to 6 months after exposure terminates (see AR 40-26, TB MED 236).

d. Physical Exertion. Any employee in an occupation requiring moderate or severe physical exertion should have a preplacement examination to insure a high degree of physical fitness. Periodic examinations are worthwhile to insure that workers remain in adequate physical condition. Annual examinations are usually needed for older workers or workers with known

health impairments that may deteriorate with time. Younger workers in good health seldom have significant changes in their physical status from one year to the next and less frequent examinations are more practical. The exact program to be developed should take into consideration available medical resources and the age and health of the individual workers.

e. Ionizing Radiation. All workers who will be potentially exposed to sources of ionizing radiation should have a complete preplacement examination including a history of all previous radiation exposure, including diagnostic and therapeutic radiation. Also, a complete blood count (CBC) including hematocrit, hemoglobin, white blood cell count and differential should be performed. Annual or periodic physical examinations are usually not warranted solely because of potential exposure to radiation. Personnel monitoring is far more effective in determining the amount of exposure. All personnel potentially exposed to gamma radiation or x-ray should be included in a film badge program and additional monitoring such as whole body counting or biological assays are indicated for specific exposures as shown in Appendix E. A cumulative exposure record (DD Form 1141) should be maintained for each individual in the Radiation Film Badge Program. Bioassay results should be filed in the laboratory report section of the medical file. The maximum allowable occupational exposure is not to exceed 5 Rem per year and the total cumulative dose should not be allowed to exceed 5 Rem for each year of age over 18 years. The formula is thus: maximum permissible exposure = 5(N-18) Rem, where N is defined as the age of the employee in years.

f. Chemical Exposures. A large number of specific chemical exposures are covered in Chapter 2 of this guide; however, all exposures that might be encountered in the Army are not included. Only those chemicals in widespread use have been listed. Data presented for each substance include: the TLV® and Time Weighted Average (TWA), common uses, occupations with potential exposure, toxicology, recommended medical surveillance, and references. However, it must be noted that in selecting procedures for medical surveillance, the criteria of specificity, cost, practicality and availability were considered to the greatest extent. It is fully realized that, for example, a Bromsulphalein retention test is a much more sensitive indicator of hepatic function than a random enzyme analysis; however, serum glutamic oxaloacetic transaminase (SGOT) and serum glutamic pyruvic transaminase (SGPT) measurements are better suited as screening tools. This does not preclude the use of more definitive tests by the physician when he feels they are indicated.

TLV® - Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1973, by American Conference of Governmental Industrial Hygienists.

g. Miscellaneous. Specific regulations may exist for vehicle operators' examinations and should be followed whenever applicable. Vision should be tested at least every 3 years and should include visual acuity, depth perception, and peripheral vision. Physical examinations, if required, should depend upon the age and health of the individual and emphasize visual motor skills and neuromuscular coordination (FPM 339).

CHAPTER 2. SPECIFIC CHEMICAL EXPOSURES

Acetone

TWA - 1,000 ppm (2,400 mg/m^3)
TLV® - 1,000 ppm (2,400 mg/m^3)
Use - Solvent.
Occupations with potential exposure -

Acetic acid makers	Drug makers
Acetic anhydride makers	Electronic equipment cleaners
Acetone workers	Electronic equipment dryers
Acetylene cylinder fillers	Explosive makers
Adhesive makers	Glycol makers
Bronzers	Iodoform makers
Celluloid makers	Isoprene makers
Cellulose acetate makers	Lacquerers
Chloroform makers	Lacquer makers
Diacetone alcohol makers	Lubricating oil dewaxers

Toxicology -

Local effects - Dermatitis after repeated exposures. Irritation of conjuntivae and mucous membranes of nose and throat at high concentrations (2500 ppm).

Systemic effects - Narcosis, headache, nausea, vomiting, dizziness, and incoordination.

Medical Surveillance - Usually *none* is required. Acetone may be determined directly in blood or urine.

References - Henson, E.V.: Toxicology of Some Aliphatic Ketones. J. Occup. Med. 1:607, 1959.
See General References (Appendix A).

Acetonitrile (methyl cyanide, cyanomethane, ethanenitrile)

TWA - 40 ppm (70 mg/m^3)
TLV® - 40 ppm (70 mg/m^3)
Uses - Solvent, extractant, chemical intermediate.
Occupations with potential exposure -

Acetonitrile workers	Petroleum hydrocarbon purifiers
Animal oil processors	Tank coaters

Toxicology -

Local effects - Contact dermatitis due to primary irritation by either liquid or concentrated vapor.

Systemic effects - Hydrolyzes to cyanide which is detoxified to thiocyanate. Late symptoms may be due to thiocyanate toxicity. Inhalation of high concentrations can produce headache, weakness, shortness of breath, nausea, diarrhea, chest and abdominal pain, gray color, bleeding from mucous membranes, convulsions, coma, and death. Liver and kidney damage may also occur.

Medical Surveillance - SGOT and UA annually. Exclude asmathics and those with chronic pulmonary disease. Urinary thiocyanate level monthly.

Remarks - Special Diagnostic Test: Determination of blood cyanide, serum and urinary thiocyanate.

References - Amdur M.L.: Accidental group exposure to acetonitrile; a clinical study. J. Occup. Med. 1:627, 1959.
Rieders, F. and Brieger, H.; Lewis, C.E., and Amdur, M.L.: What is the mechanism of toxic action of organic cyanide? J. Occup. Med. 3:482, 1961.

Ammonia

TWA - 50 ppm (35 mg/m^3)
TLV® - 25 ppm (18 mg/m^3)
Uses - Refrigerant, refining of petroleum, manufacture of explosives, dyes, and plastics.
Occupations with potential exposure -

- Acetylene workers
- Aluminum workers
- Amine makers
- Ammonia workers
- Ammonium salt makers
- Annealers
- Braziers
- Bronzers
- Case hardeners
- Coal tar workers
- Cyanide makers
- Diazotypy machine operators
- Dye intermediate makers
- Dye makers
- Electroplaters
- Electrotypers
- Explosive makers
- Galvanizers
- Gas purifiers
- Gas workers, illuminating
- Glass cleaners
- Ice cream makers
- Ice makers
- Laboratory workers, chemical
- Latex workers
- Manure handlers
- Metal extractors
- Metal powder processors
- Mirror silverers
- Nitric acid makers
- Organic chemical synthesizers
- Petroleum refinery workers
- Photoengravers
- Plastic cement mixers
- Refrigeration workers
- Resin makers
- Rocket fuel makers
- Rubber cement mixers
- Rubber workers
- Sewer workers
- Shoe finishers
- Steel makers
- Sulfuric acid workers
- Tanners
- Tannery workers
- Urea makers
- Vulcanizers
- Water base paint workers
- Water treaters

Toxicology -

Local effects - Contact with anhydrous liquid ammonia or with aqueous solutions is intensely irritating to mucous membranes, eyes, and skin. Eye symptoms range from lacrimation, blepharospasm, and palpebral edema to corneal ulceration and blindness. There may be corrosive burns of skin or blister formation. Ammonia gas is also irritating to eyes and moist skin.

Systemic effects - Mild to moderate exposure to gas can produce headache, salivation, burning of throat, anosmia, perspiration, nausea, vomiting, and substernal pain. Irritation of ammonia gas in eyes and nose is sufficiently intense to compel workers to flee. If escape is not possible, there is irritation of lower respiratory tract with production of cough, glottal edema, pulmonary edema, or respiratory arrest. Bronchitis or pneumonia may follow a severe exposure if patient survives. Urticaria is a rare allergic manifestation from inhalation of gas.

Medical Surveillance - None recommended. Exposure is usually manifested by acute symptomatology.

Remarks - Odor threshold is 50 ppm.

References - See General References (Appendix A).

Amyl Acetate (isoamyl acetate, pear oil, banana oil, amyl acetic ester)

TWA - 100 ppm (525 mg/m^3)
TLV® - 100 ppm (525 mg/m^3)
Uses - Glues, dyes, enamels, explosives, polishes, gild, lacquer removers, dope, batteries, dry cleaning, Hefner lamps.
Occupations with potential exposure -

- Battery makers, storage
- Bookbinders
- Bronzers
- Bronzing liquid makers
- Dry cleaners
- Dyers
- Enamelers
- Explosive workers
- Furniture polishers
- Lacquer removers
- Leather workers
- Nitrocellulose workers
- Plastic makers
- Printers
- Shellackers
- Textile dyers
- Varnishers

Toxicology -

Local effects - Vapor is irritating to eyes and respiratory tract, and has produced laryngitis and glottal edema. Prolonged contact with liquid produced dry, scaly, and fissured dermatitis.

Systemic effects - Vapor has a narcotic action, and prolonged inhalation can produce fatigue, headache, vertigo, tinnitus, mental confusion, and somnolence. Overexposure is usually prevented by irritant warning property.

Medical Surveillance - Usually none is required.

References - See General References (Appendix A).

Amyl Alcohol (fusel oil, grain oil, potato spirit, potato oil, isoamyl alcohol)

TWA - 100 ppm (360 mg/m^3)
TLV® - 100 ppm (360 mg/m^3)
Uses - Lacquer, explosives, plastics, rubber, paint, stripping, hydraulic fluids.
Occupations with potential exposure -

Antifreeze makers	Painters
Explosive makers	Plastic workers
Lacquerers	Rubber makers
Mechanics	Shoe finishers
Nitrocellulose workers	Varnishers

Toxicology -

Local Effects - Liquid and vapor are irritating to eyes, mucous membranes, and skin.

Systemic effects - Early effects are irritation of nose and throat, followed by nausea, vomiting, facial flushing, headache, double vision, dizziness, and muscular weakness. Prolonged exposures to high concentrations can cause delirium, loss of consciousness, and death.

Medical Surveillance - None required. If an acute exposure is suspected, determination of amyl alcohol content of blood is possible (see reference).

Reference - von Oettingen, W.F.: Poisoning, a Guide to Clinical Diagnosis and Treatment. W.B. Saunders Co., Philadelphia, 1958.

Arsine

TWA - 0.05 ppm (0.2 mg/m^3)
TLV® - 0.05 ppm (0.2 mg/m^3)
Uses - Arsine may be produced wherever nascent hydrogen comes in contact with arsenic. The hydrogen is usually produced by the action of acid upon a metal, the arsenic being present as an impurity in the metal or in the acid.
Occupations with potential exposure -

Acetylene workers	Galvanizers
Acid dippers	Lead burners
Aniline workers	Metal cleaners
Bronzers	Nitrocellulose makers
Chemical producers	Plastic workers
Dye makers	Plumbers
Electroplaters	Solderers
Etchers	Tinners

Toxicology -

Local Effects - Bronze discoloration of skin.

Systemic Effects - Hemolysis of red blood corpuscles with resulting anemia and jaundice. Peripheral neuritis, visual disturbances, and delirium. Chronic intoxication may result in nephritis, myocarditis, and hepatitis. Garlic-like odor may be noted on breath.

Medical Surveillance - Urinary arsenic levels should be done at least yearly. Levels greater than 0.1 mg/l are indicative of excessive exposure. Reticulocytosis, hemoglobinurea, and albuminurea are also useful indicators.

Remarks - Interim reticulocyte counts can be used as a rapid and a convenient indicator of exposure.

References - Bulmer, F.M.R.; Rothwell, H.E.; Polack, S.E., and Stewart, D.W.: Chronic arsine poisoning among workers employed in the cyanide extraction of gold; a report of fourteen cases. J. Indust. Hyg. & Toxicol. 22:111, 1940.
Elkins, H.B.: The Chemistry of Industrial Toxicology. 2nd ed. John Wiley & Sons, New York, 1959.

Josephson, C.J.; Pinto, S.S., and Petronella, S.J.: Arsine; electrocardiographic changes produced in acute human poisoning. A.M.A. Arch. Indust. Hyg. & Occup. Med. 4:43, 1951.

Arsenic (Inorganic)

TWA - 0.5 mg/m^3
TLV® - 0.5 mg/m^3
* - 0.05 mg/m^3 (proposed) (see Remarks)
Uses - Alloying agent, sludge control in lubricating oils, antifouling paint, pigment production, pesticide production, glass manufacture, textile printing.
Occupations with potential exposure -

Alloy makers	Lead shot makers
Aniline color makers	Lead smelters
Arsenic workers	Leather workers
Babbitt metal workers	Painters
Boiler operators	Paint makers
Brass makers	Petroleum refinery workers
Bronze makers	Pigment makers
Bronzers	Printing ink workers
Ceramic enamel makers	Rodenticide makers
Ceramic makers	Semiconductor compound makers
Copper smelters	Silver refiners
Drug makers	Taxidermists
Dye makers	Textile printers
Enamelers	Tree sprayers
Fireworks makers	Type metal workers
Glass makers	Water weed controllers
Gold refiners	Weed sprayers
Herbicide makers	Wood preservative makers
Insecticide makers	Wood preservers

Toxicology -

Local effects - Contact with arsenic may produce facial and flexural eczematous dermatitis, ulcerations of the skin, conjunctivitis, rhinitis, nasal perforation, folliculitis, and pustules. Most of these effects are due to primary irritation, but some cases of contact dermatitis are due to allergic hypersensitivity. Prolonged absorption may result in generalized "rain drop" hyperpigmentation, premalignant keratoses on palms and soles, hair loss, and nail dystrophy.

Systemic Effects - Acute systemic poisoning from ingestion produces a violent gastroenteritis which may be followed by nephritis, hepatitis, or neuritis, but this type of

poisoning is rare in industry. A massive inhalation exposure can produce bronchitis, but acute systemic intoxication is unlikely by this route. When arsenical intoxication occurs in industry, it is usually chronic in form. High exposures are frequently tolerated without symptoms of systemic poisoning. Chronic exposure is characterized by insidious onset of malaise, abdominal complaints, pruritus, weakness, anorexia, and weight loss. There may be gingivitis and stomatitis with garlic breath. However, the garlic breath may be due to contamination with tellurium. Peripheral nerve degeneration resulting in progressive sensory alterations and motor disturbances is common. Kidney and liver damage may also occur. Prolonged inhalation of dust may result in laryngitis and bronchitis. Arsenic has been suspected, but not proved, as a cancer producing agent in the liver and lungs.

Medical Surveillance - Medical surveillance shall be made available as specified below for all workers occupationally exposed to arsenic.

a. Preplacement and annual medical examinations shall include:

(1) Comprehensive or interim work history.

(2) Comprehensive or interim medical history.

(3) Sputum cytology.

(4) Careful examination of the skin for the presence of hyperpigmentation, keratoses, or other chronic skin lesions. Skin examinations shall be repeated bimonthly. Care shall be taken to observe and record the location, condition, appearance, size, and any changes in all such lesions.

(5) An evaluation of the advisability of the worker's using negative- or positive-pressure respirators. Such evaluation to include, at a minimum, determination of Forced Vital Capacity (FVC) and Forced Expired Volume in 1 second (FEV_1).

(6) 14" X 17" posterior-anterior chest x-rays to be accomplished triennially in employees with long-term exposure.

b. Medical records shall be maintained for persons employed 1 or more years in work involving exposure to arsenic. X-rays for the 5 years preceding termination of employment and all medical records with pertinent supporting documents shall be maintained at least 20 years after the individual's employment is terminated.

Remarks - Routes of Entry: Ingestion or inhalation of dust or fume. Special Diagnostic Tests: Analysis of urine, hair, or nails for abnormal amounts of arsenic trioxide. The presence of arsenic in urine in amounts greater than 0.2 mg/l, is strongly suggestive of excessive absorption. See Elkins, 1959, and Vallee et al., 1960. *See NIOSH Criteria Document (Appendix D).

References - Dinman, B.D.: Arsenic; chronic human intoxication. J. Occup. Med. 2:137, 1960.
Elkins, H.B.: The Chemistry of Industrial Toxicology. 2nd ed. John Wiley and Sons, New York, 1959.
Holmqvist, L.: Occupational arsenical dermatitis; a study among employees at a copper-ore smelting works including investigations of skin reactions to contact with arsenic compounds. Acta dermat-venereol. Supp. 26, 1951.
Pinto, S.S. and McGill, C.M.: Arsenic trioxide exposure in industry. Indust. Med & Surg. 22:281, 1953.
Vallee, B.L.; Ulmer, D.D., and Wacker, W.E.C.: Arsenic toxicology and biochemistry. A.M.A. Arch. Indust. Health. 21:132, 1960.

Asbestos

TWA - 5 fibers, longer than 5 μ, per cc of air.
TLV® - 5 fibers, longer than 5 μ, per cc of air.
Uses - Floor tiles, cements, roofing tiles and shingles, insulation materials, acoustical products.
Occupations with potential exposure -

Construction workers	Pipe coverers
Insulation workers	Textile workers

Toxicology -

Local effects - Not significant.

Systemic effects - Asbestos is a known carcinogen causing mesothelioma of the pleura and peritonium and possibly bronchogenic carcinoma. Prolonged inhalation of asbestos fibers between 20 and 50 microns long may result in the production of a typical pulmonary fibrosis which may be accompanied by severe respiratory disability. On the basis of experimental studies of asbestosis, it was reported in 1951 that this fibrosis is due to the mechanical action of the asbestos fiber. The fibers, upon being deposited in the terminal bronchioles, initiate a tissue response which results in the coating of the fiber with the ultimate production of what is known as the asbestos or asbestosis body. This response appears to be a defense mechanism of the lung. If large quantities of the fibers are inhaled over a prolonged period of time, characteristically 10 to 20 years, the tissue reaction progresses until a generalized, diffuse fibrosis becomes evident. This fibrosis is seen first in the lower lobes of the lungs but eventually, if exposure continues, appears in the other lobes as well. Respiratory insufficiency and cardiac failure may supervene. It is of considerable interest and significance that asbestos fibers smaller than about 20 microns in length are thought to be incapable of initiating a fibrogenic response.

Medical Surveillance - Biennial history, physical examination, pulmonary function testing, and chest x-ray. These tests to be done annually on those employees with 10 years exposure or abnormal findings.

Remarks - See NIOSH criteria document (Appendix D).

References - Anderson, J. and Campagna, F.A.: Asbestosis and carcinoma of the lung. Case report and review of literature. Arch. Environ. Health. 1:27, 1960.
Doll, R.: Mortality from lung cancer in asbestos workers. Brit. J. Indust. Med. 12:81, 1955.
Isselbacher, K.J.; Klaus, H., and Hardy, H.L.: Asbestosis and bronchogenic carcinoma. Am. J. Med. 15:721, 1953.
Keal, E.E.: Asbestosis and abdominal neoplasms. Lancet 2:1211, 1960.
Leathart, G.L.: Clinical, bronchographic, radiological and physiological observations in ten cases of asbestosis. Brit. J. Indust. Med. 17:213, 1960.
Smith, K.W.: Pulmonary disability in asbestos workers. A.M.A. Arch. Indust. Health 12:198, 1955.
Vorwald, A.J.; Durkan, T.M., and Pratt, P.C.: Experimental Studies of Asbestosis. A.M.A. Arch. Ind. Hyg. Occup. Med. 3:1, 1951.
Wagner, J.C.; Sleggs, C.A., and Marchand, P.: Diffuse pleural mesothelioma and asbestos exposure in the North Western Cape Province. Brit. J. Indust. Med. 17:260, 1960.

Barium and Compounds

TWA - 0.5 mg/m^3 (soluble salts)
TLV® - 0.5 mg/m^3 (soluble salts)
Uses - Glass, paint and rubber manufacture.
Occupations with potential exposure -

Bearing packers	Electroplaters
Black ash workers	Embalmers
Boiler operators	Enamelers
Crystal makers	Explosive makers
Disinfectant makers	Glazers
Dyers	

Toxicology -

Local effects - The soluble barium salts are irritating to skin and mucous membranes and may produce dermatitis, conjunctivitis, and marked bronchial irritation. Barium sulfide is known for its depilatory and bleaching action.

Systemic Effects - The soluble barium salts are highly toxic. Barium stimulates smooth, striated, and cardiac muscle and may produce violent peristalsis, arterial hypertension, muscle twitching, and cardiac dysfunction. Barium sulfate is relatively insoluble and therefore innocuous when ingested; however, prolonged inhalation has been reported to cause a benign form of pneumoconiosis known as baritosis.

Medical Surveillance - Annual physical examination with emphasis upon the cardiovascular system (blood pressure).

Remarks - Chest x-ray changes are seen and are of no clinical significance.

Reference - Pendergrass, E.P., and Greening, R.R.: Baritosis; report of a case. A.M.A. Arch. Indust. Hyg. & Occup. Med. 7:44, 1953.

Benzene (benzol, phenyl hydride, coal naphtha, phene, benzole, cyclohexatriene)

TWA - 10 ppm (32 mg/m^3), 25 ppm (80 mg/m^3)C
TLV® - 25 ppm (80 mg/m^3), Skin, C
Uses - Solvent, chemical intermediate, fuel constituent.
Occupations with potential exposure -

Airplane dope makers	Maleic acid makers
Alcohol workers	Millinery workers
Aniline makers	Nitrobenzene makers
Asbestos prod impregnators	Nitrocellulose workers
Battery makers, dry	Oil processors
Benzene workers	Organic chemical synthesizers
Bronzers	Painters
Burnishers	Paraffin processors
Carbolic acid makers	Petrochemical workers
Chlorobenzene makers	Petroleum refinery workers
Coal tar workers	Picric acid makers
Cobblers	Pottery decorators
Degreasers	Printers
Dichlorobenzene makers	Resin makers
Diphenyl makers	Rubber cementers
Dry cleaners	Rubber gasket makers
Dye makers	Rubber makers
Explosive makers	Solvent makers
Furniture finishers	Stainers
Hair dressers	Styrene makers
Herbicide makers	Synthetic fiber makers
Histology technicians	Type cleaners
Lacquer makers	Wax makers
Leather makers	Welders
Lithographers	Wire insulators

Toxicology -

Local effects - Exposure to liquid or vapor may produce primary irritation of skin, eyes, and mucous membranes of upper respiratory tract. Skin effects may include erythema, vesiculation, or a dry, scaly dermatitis.

Systemic effects - Acute high exposures are responsible for initial exhilaration followed by signs and symptoms of central nervous system depression, including drowsiness, fatigue, headaches, dizziness, loss of consciousness,

convulsions, and death. Chronic low-level exposures may produce alterations of blood elements most commonly resulting in anemia, leukopenia, and thrombocytopenia. The bone marrow effects may be normal, hyperplastic, or hypoplastic and do not necessarily reflect the state of peripheral blood. Symptoms and signs relative to depression of these blood cellular elements include headache, fatigue, dizziness, loss of appetite, weakness, breathlessness, bleeding from the nose and other mucous membranes, purpura, easy bruising, and proneness to infection. These effects generally improve after removal of the worker from areas of excessive exposure.

Medical Surveillance - Monthly CBC's should be accomplished on all workers exposed to benzene vapor. Urinary sulfate ratios should be done monthly. A ratio of less than 0.7 is indicative of exposure (Inorganic/Total SO_4). A ratio of 0.6 is indicative of extremely hazardous exposure. Urinary phenol determinations are also a valid indicator of exposure.

Remarks - Benzene is a suspected carcinogen and <u>every attempt should be made to eliminate exposure</u>. All forms of acute and chronic leukemia have been observed in workers with benzene intoxication.

References - Gerarde, H.W.: Toxicology and Biochemistry of Hydrocarbons. Elsevier Publishing Co., Amsterdam, and Princeton, N.J., 1960.
Hueper, W.C.: Carcinogens in the human environment. Arch. Path. 71:237, 1961.

Benzidine

TWA - See Carcinogens (Appendix F)
TLV® - 0 ppm (0 mg/m^3)
Uses - Laboratory reagent, manufacture of dye and plastics.
Occupations with potential exposure -

Benzidine workers	Laboratory workers
Chemists	Plastic makers
Dye workers	

Toxicology -

Local Effects - Primary irritant contact dermatitis has been reported; allergic contact dermatitis is rare.

Systemic effects - Benzidine is a urinary bladder carcinogen. The actual carcinogens are probably metabolites 4,4-diamino-3-diphenyl hydrogen sulfate or the orthohydroxy benzidine. Urinary manifestations are frequency, dysuria, and hematuria. Benzidine is unimportant as a methemoglobin former.

Medical Surveillance - Microscopic examination of the urine for red blood cells semiannually. Urinary cytology annually.

Remarks - OSHA requires reporting of use, medical surveillance programs implemented, and monitoring procedures utilized.

Reference - 29 CFR 1910.93, Federal Register, Vol. 39, No. 20, Part 111, 29 January 1974.

Beryllium

TWA - 0.002 mg/m^3, 0.005 mg/m^3 C
TLV® - 0.002 mg/m^3
Uses - Alloys, electrical insulators, manufacture of ceramic parts, crucibles, thermal coatings, applications in nuclear reactors, inertial guidance systems, rocket motor parts, heat shields, rotor blades, airplane brakes, jewelry, dental plates, furnace bricks, spark plugs.
Occupations with potential exposure -

Beryllium alloy machiners	Dental technicians
Beryllium alloy makers	Electric equipment makers
Beryllium compound makers	Fluorescent screen makers
Beryllium copper founders	Gas mantle makers
Beryllium copper grinders	Missile technicians
Beryllium copper polishers	Neon sign workers
Beryllium extractors	Neon tube makers
Beryllium metal machiners	Nonsparking tool makers
Beryllium phosphor makers	Nuclear physicists
Beryllium workers	Nuclear reactor workers
Cathode ray tube makers	Precision instrument makers
Ceramic makers	Refractory material makers

Toxicology -

Local Effects - Contact with beryllium salts may produce contact dermatitis of the hypersensitivity or primary irritant type. Contamination of abrasions or superficial lacerations with the more soluble beryllium salts may cause a chronic, indolent ulcer. Intracutaneous implantation of spicules of beryllium metal or certain beryllium salts may result in the formation of a low-grade granulomatous lesion. Irritation of conjunctiva and cornea may follow contact with beryllium salts, as may rhinitis and nasopharyngitis.

Systemic Effects - Inhalation of beryllium dust or fume may result in the production of systemic disease either of an acute or of a chronic nature, depending upon the extent of exposure and the nature of the beryllium compound involved.

Acute beryllium disease has resulted from exposure to beryllium compounds in industrial plants producing beryllium from the ore, in metallurgic and ceramics laboratories, and in the fluorescent lamp industry. The

following beryllium compounds, in addition to the metal, have been shown to cause acute poisoning: beryllium oxide, sulfate, fluoride, hydroxide, and chloride. The cases associated with the preparation of phosphors involved exposure to beryllium oxide and to zinc beryllium silicate.

Chronic beryllium poisoning has been reported as resulting from exposure in plants handling beryllium phosphors, in beryllium copper founding, in ceramics laboratories, in metallurgic shops and in plants producing beryllium compounds from the ore. This disease has also been reported as occurring among individuals exposed to atmospheric pollution in the vicinity of plants processing beryllium and in persons dwelling in the same household as beryllium workers. Inhalation of the dust of beryl, the beryllium ore, has produced to date no known cases of acute or chronic beryllium poisoning.

Granulomatous lesions of the skin, liver, kidneys, spleen, and lymph nodes may be seen in some patients with beryllium disease; however, the most striking features of both the acute and chronic forms are referable to the lungs.

Although of dissimilar roentgenologic and histopathologic appearance, both the acute and the chronic forms of beryllium poisoning have some similar signs and symptoms. These include a relatively nonproductive cough, progressive dyspnea, anorexia, and loss of weight. The chief differences between the two forms are seen in the suddenness of onset and in the rate of progression. In neither the acute nor the chronic form of beryllium disease has there been reported any evidence to suggest that microorganisms might play a significant role in pathogenesis.

In the acute pulmonary form, the symptoms of pneumonitis may appear within several hours to several weeks following the initial exposure of the patient to beryllium, and the radiographic changes may become noticeable within from 1 to 3 weeks after the onset of symptoms. There is usually rapid progression of signs and symptoms including dyspnea, anorexia, and extreme weight loss. There is generally complete recovery within

a period of about 6 months. Cases which terminate fatally usually do so as a result of acute cor pulmonale.

The typical pattern shown by the chest roentgenogram in acute beryllium pneumonitis is a bilateral, patchy infiltrate which resembles the pattern seen in pulmonary edema. This infiltrate may be superseded by a coarse, nodular appearance before final clearance or recovery occurs.

The pathologic lesion seen in the lung in acute beryllium disease is a chemical pneumonitis or bronchoalveolitis, the severity of which is usually proportional to the intensity of exposure.

In chronic beryllium disease, the symptoms are generally delayed in onset and persistent in character. They are commonly precipitated or exacerbated by stresses such as pregnancy, respiratory infection, and thyrotoxicosis. The pulmonary manifestations may be mimicked by symptoms of other lung diseases, such as the fibrosing interstitial pneumonitis of the Hamman-Rich syndrome and the pulmonary granulomatosis of sarcoidosis. Dyspnea, cough, anorexia, and weight loss are among the most frequent manifestations of chronic beryllium disease. As the disease progresses, signs and symptoms of cor pulmonale may supervene.

The earliest roentgenographic evidence of pulmonary involvement may appear within a few weeks of the first symptoms of the disease. The most significant feature of the roentgenogram is a uniform distribution of fine granulation, with variation from a ground glass appearance through a diffuse reticular pattern to distinct nodulation superimposed on a granular background.

Additional aid in the diagnosis of chronic beryllium poisoning may be gained through the study of pulmonary function, by use of the beryllium patch test, through determinations of the beryllium content of body fluids, and through histologic and chemical study of the surgical lung biopsy.

It is generally accepted that the basic pulmonary physiopathology in this disease is an alveolar-capillary

block. This diffusion defect can usually be demonstrated in patients with chronic beryllium disease and, while it is not pathognomonic, it may often be helpful in ruling out certain others of the pulmonary granulomatoses.

The place of the patch test in the diagnosis of beryllium disease is uncertain. Some investigators have shown excellent correlation between positive skin reactions to beryllium and proved poisoning, while others have not been able to show such correlation and have pointed out certain hazards inherent in the test itself.

The finding of increased amounts of beryllium in the body tissues and fluids does not, by any means, justify in itself a diagnosis of beryllium disease, nor does the absence of increased amounts of beryllium rule out chronic beryllium poisoning.

The more liberal application of the use of the surgical lung biopsy has been of major aid in the diagnosis of beryllium disease. It must be pointed out, however, that in some cases even the most experienced pathologist may find it impossible to distinguish between this condition and sarcoidosis by examination of histologic sections.

There is no available evidence to implicate beryllium disease as predisposing to pulmonary tuberculosis. Moreover, a causal relationship between beryllium disease and lung cancer has not been established.

Medical Surveillance - A comprehensive preplacement history and physical examination for all worker applicants shall be provided to include, as a minimum, a 14" by 17" chest roentgenogram, baseline pulmonary function testing (FVC and $FEV_{1.0}$), and a base line weight. Each worker exposed to beryllium shall receive an annual evaluation that includes:

a. Spirometry, including FVC and $FEV_{1.0}$.

b. A medical history questionnaire that includes presence and degree of respiratory symptoms, i.e., breathlessness, cough, sputum production, and wheezing.

c. A 14" by 17" chest x-ray. Medical records shall be maintained for at least 20 years.

Remarks - See NIOSH Criteria Document (Appendix D). Special Diagnostic Tests: Analysis of urine and tissue for abnormal amounts of beryllium. See Cholak, 1959.

References -
Breslin, A.J. and Harris, W.B.: Health protection in beryllium facilities, summary of ten years of experience. HASL-36. U.S. Atomic Energy Commission, New York, 1958.
Cholak, J.: The analysis of traces of beryllium. A.M.A. Arch. Indust. Health. 19:205, 1959.
Curtis, G.H: The diagnosis of beryllium disease, with special reference to the patch test. A.M.A. Arch. Indust. Health. 19:150, 1959.
Eisenbud, M.; Wanta, R.C.; Dustan, C.; Steadman, L.T.; Harris, W.B., and Wolf, B.S.: Non-occupational berylliosis. J. Indust. Hyg. & Toxicol. 31:282, 1949.
Gross, P.: The concept of the Hamman-Rich syndrome; a critique. Am. Rev. Resp. Dis. 85:828, 1962.
Hardy, H.L.: Beryllium disease, a continuing diagnostic problem. Am. J. Med. Sc. 242:150, 1961.
Hardy, H.L.: Reaction to toxic beryllium compounds; terminology. J. Occup. Med. 4:532, 1962. Regards beryllium disease as a systemic intoxication, not as a pneumonoconiosis.
Lewis, C.E.: Workshop on beryllium. J. Occup. Med. 4:80, 1962.
Muschenheim, C.: Some observations on the Hamman-Rich disease. Am. J. Med. Sc. 241:279, 1961.
Peyton, M.F. and Worcester, J.: Exposure data and epidemiology of the beryllium case registry, 1958. A.M.A. Arch. Indust. Health. 19:94, 1959.
Sterner, J.H. and Eisenbud, M.: Epidemiology of beryllium intoxication. A.M.A. Arch. Indust. Hyg. & Occup. Med. 4:123, 1951.

Bismuth and Compounds

TWA - Not established.
TLV® - 5 mg/m^3
Uses - Dyes, ceramics, antidiarrheals, cosmetics, disinfectants, fuses, luminous paints and enamels, permanent magnets, semiconductors, solder, tin luster.
Occupations with potential exposure -

Dyers	Semiconductor makers
Laboratory workers	Solder makers

Toxicology -

Local effects - Bismuth subnitrate may cause skin irritation.

Systemic effects - Basic salts are insoluble and exhibit low oral toxicity. Formerly used in an injectable form as a treatment for syphilis. Toxic symptoms following injection include loss of appetite, foul breath, gingivitis, stomatitis, weakness, and diarrhea. Toxic hepatitis and nephritis rarely occur. No poisonings related to occupation have been found in the literature.

Medical Surveillance - None required.

Remarks - Special Diagnostic Tests: Analysis of blood and urine for excessive amounts of bismuth.

References - Browning, E.: Toxicity of Industrial Metals. Butterworths, London, 1961.
von Oettingen, W.F.: Poisoning, a Guide to Clinical Diagnosis and Treatment. 2nd ed. W. B. Saunders Co., Philadelphia, 1958.

Boranes (boron hydrides)

TWA - Diborane, 0.1 ppm (0.1 mg/m^3)
Pentaborane, 0.005 ppm (0.01 mg/m^3)
Decaborane, 0.05 ppm (0.3 mg/m^3), Skin
Boron trifluoride, 1 ppm (3 mg/m^3) C
TLV® - Diborane, 0.1 ppm (0.1 mg/m^3)
Pentaborane, 0.005 ppm (0.01 mg/m^3)
Decaborane, 0.05 ppm (0.3 mg/m^3)
Boron trifluoride, 1 ppm (3 mg/m^3)
Uses - Propellants.
Occupations with potential exposure -

Diborane	
Diborane workers	Rocket fuel handlers
Organic chemical synthesizers	Rocket fuel makers
Pentaborane	
Gasoline additive makers	Rocket fuel handlers
Pentaborane workers	Rocket fuel makers
Decaborane	
Chemical scavenger makers	Insecticide makers
Chemical stabilizer makers	Organic chemical synthesizers
Decaborane workers	Resin makers
Dyers	Rocket fuel handlers
Gasoline additive makers	Rocket fuel makers
Boron trifluoride	
Boron trifluoride workers	Nuclear instrument makers
Fumigators	Organic chemical synthesizers

Toxicology -

Local effects - May produce primary skin irritation and conjunctivitis.

Systemic effects - Boron hydrides (diborane, pentaborane, decaborane) are the most important compounds of this group. Inhalation of diborane may result in chest tightness, cough, headaches, nausea, chills, dizziness, and drowsiness. These complaints are generally of short duration. Pneumonia may develop following severe exposures. Pentaborane and decaborane produce predominantly central nervous system symptoms and signs. Hyperexcitability, headaches, muscle twitching, convulsions, dizziness, disorientation, and unconsciousness may occur early or be delayed for 24 hours or more following excessive exposures to these

compounds. Skin and respiratory tract irritation and central nervous system effects have been reported from animal experiments with amine and alkyl boranes. The alkyl boranes seem to be more toxic than the amine compounds and decaborane, but less toxic than pentaborane. The major effect of repeated inhalation of boron trifluoride in laboratory animals was respiratory irritation which resulted in a pneumonitis.

Medical Surveillance - No specific recommendations.

Remarks - Special Diagnostic Tests: Analysis of boron in blood, urine and body tissues.

References - Jacobson, K.H.: Transactions symposium on health hazards of military chemicals. CWL Special Publication 2-10. US Army Chemical Warfare Laboratories, Army Chemical Center, Maryland, 1958.

Lowe, H.J. and Freeman, G.: Boron hydride (borane) intoxication in man. A.M.A. Arch. Indust. Health 16:523, 1957.

Office of Director of Defense Research and Engineering, Department of Defense: The Handling and Storage of Liquid Propellants. The Defense Department, Washington, D.C., 1961.

Roush, G., Jr: The toxicology of the boranes. J. Occup. Med. 1:46, 1959.

n-Butyl Alcohol (1-butanol, butyl hydroxide, propylcarbinol, butyric alcohol, hydroxybutane)

TWA - 100 ppm (300 mg/m^3)
TLV® - 100 ppm (300 mg/m^3)
Uses - Dyes, hydraulic fluid, lacquers, plastics, shellac, stain, adhesives, varnish.
Occupations with potential exposure -

Butyl acetate makers	Nitrocellulose makers
n-Butyl alcohol workers	Photographic film makers
Butyric acid makers	Plasticizer makers
Detergent makers	Polyvinyl resin makers
Di-n-butyl phthalate makers	Rubber cement makers
Dye makers	Shellac makers
Hydraulic fluid makers	Stainers
Lacquerers	Stain makers
Lacquer makers	Urea-formaldehyde resin makers
Melamine resin makers	Varnish makers

Toxicology -

Local effects - Vapor is an irritant to conjunctiva and mucous membranes of upper respiratory tract. A peculiar keratitis characterized by numerous vacuoles has been reported. Liquid is a primary skin irritant.

Systemic effects - No cases of systemic toxicity in humans have been reported, either from n-butyl alcohol or its isomers.

Medical Surveillance - None required.

Reference - Henson, E. V.: The toxicology of some aliphatic alcohols; part 2. J. Occup. Med. 2:497, 1960.

n-Butylamine

TWA - 5 ppm (15 mg/m^3) C (Skin)
TLV® - 5 ppm (15 mg/m^3)
Uses - Chemical intermediate, corrosion inhibitors, paint stripper.
Occupations with potential exposure -

n-Butylamine workers	Emulsifier makers
Butylaminophenol makers	Insecticide makers
Dye makers	Petroleum dewaxers

Toxicology -

Local effects - Liquid is irritating to skin and eyes and produces severe contact dermatitis and corneal injury.

Systemic effects - Vapor is irritating to respiratory tract and can produce pulmonary edema. Stimulation of the central nervous system is followed by depression, convulsions, and narcosis.

Medical Surveillance - None required.

References - See General References (Appendix A).

Cadmium

TWA - fume, 0.1 mg/m^3, 3 mg/m^3 C
dust, 0.2 mg/m^3, 0.6 mg/m^3 C
TLV® - 0.2 mg/m^3 for dust and 0.1 mg/m^3 for fume.
Uses - Aluminum solder, storage batteries, plating, vapor lamps, ceramics, dental amalgam, electric instruments, electroplating, engraving, lithography, paint, photoelectric cells, pigments, small arms ammunition, smoke bombs, soldering, welding.
Occupations with potential exposure -

Battery workers	Printers
Electroplaters	Smelters
Engravers	Solderers
Painters	Textile printers
Platers	Welders

Toxicology -

Local effects - Irritant to mucous membranes. Produces yellow discoloration of teeth. Certain salts may cause contact dermatitis due to allergic hypersensitization.

Systemic effects - Ingestion results in production of signs and symptoms of acute gastroenteritis. Inhalation of cadmium oxide fume may cause respiratory tract irritation with attendant sore, dry throat and metallic taste followed by cough, chest pain, and dyspnea. Bronchitis, pneumonitis, and pulmonary edema may occur as result of irritative action of fume. Additional complaints of headache, dizziness, loss of appetite and weight loss may be pronounced. Liver, kidneys, and bone marrow may be injured by the metal. It is probable that cadmium, under certain conditions, can produce chronic intoxication. Reports suggest that at least 2 years of exposure are necessary for this type of poisoning to develop. The most commonly accepted manifestations of prolonged exposure to cadmium are pulmonary emphysema, renal damage, and proteinuria. The last is not necessarily a result of renal damage and often may be demonstrated in exposed workers with apparently healthy kidneys. Other conditions that have been reported following long exposure to cadmium include anosmia, an increased incidence of nephrolithiasis, and occasional evidence of liver damage.

Medical Surveillance - Hematocrit, urinalysis, and FEV_1 tests, annually.

Remarks - Chelating agents are not indicated in the treatment of chronic poisoning.

References -

Annotation: Danger to work. Lancet 2:656, 1962. Review of Annual report of the Chief Inspector of Factories on industrial health, 1961. Cmd. 1815. Her Majesty's Stationery Office, London, 1962.

Elkins, H.B.: Chemistry of Industrial Toxicology. 2nd ed. John Wiley & Sons, New York, 1959.

Friberg, L.: Chronic cadmium poisoning. A.M.A. Arch. Indust. Health. 20:401, 1959.

Lane, R.E. and Campbell, A.C.P.: Fatal emphysema in two men making a copper cadmium alloy. Brit. J. Indust. Med. 11:118, 1954.

Smith, J.C.; Wells, A.R., and Kench J.E.: Observations on the urinary protein of men exposed to cadmium dust and fume. Brit. J. Indust. Med. 18:70, 1961.

Taylor, C.M.: Cadmium as a health hazard. Trans. Assoc. Indust. Med. Officers. 7:122, 1957.

Carbon Disulfide (carbon bisulfide, dithiocarbonic anhydride)

TWA - 20 ppm (60 mg/m^3), 30 ppm C
TLV® - 20 ppm (60 mg/m^3)
Uses - Adhesives, dry cleaners, dyes, enamels, explosives, paints and removers.
Occupations with potential exposure -

- Acetylene workers
- Ammonium salt makers
- Bromine processors
- Carbanilide makers
- Carbon disulfide workers
- Carbon tetrachloride makers
- Cellophane makers
- Cementers, rubber shoe
- Cement mixers, rubber
- Coal tar distillers
- Degreasers
- Dry cleaners
- Dyestuff makers
- Electroplaters
- Enamelers
- Enamel makers
- Explosive workers
- Fat processors
- Flotation agent makers
- Fumigant workers
- Glass makers
- Glue workers
- Iodine processors
- Laboratory workers, chemical
- Lacquer makers
- Oil processors
- Optical glass makers
- Painters
- Paint makers
- Paint remover makers
- Paraffin workers

Toxicology -

Local effects - Liquid and concentrated vapor are irritating to eyes, nose, and skin. Carbon disulfide is one of the most severe of organic solvents in its irritating action on skin.

Systemic effects - Carbon disulfide is a potent narcotic agent. Signs and symptoms of acute carbon disulfide poisoning stem from its narcotic action. In chronic carbon disulfide poisoning, the nervous system bears the brunt of damage. There may be neuritis involving peripheral and cranial nerves (optic and retrobulbar neuritis). Transient mental aberrations are common. These may include mania, depression, hallucinations, and other abnormal mental states. Gastric disturbances are common, and symptoms may simulate those complained of by patients with peptic ulcers. Heart, liver, and kidney damage may result from chronic intoxication.

Medical Surveillance - Exclude those with atherosclerotic heart disease, chronic liver and chronic renal disease. SGOT & UA annually. Neurological examination annually.

Remarks - Routes of Entry: Inhalation of vapor; percutaneous absorption of liquid or vapor.
Special Diagnostic Tests: Analysis of urine and blood for carbon disulfide (in suspected acute exposure).

Reference - Encyclopedia of Occupational Health and Safety, I: 252, International Labor Office, 1971.

Carbon Monoxide

TWA - 50 ppm (55 mg/m^3)
TLV® - 50 ppm (55 mg/m^3)
Uses - A product of incomplete combustion.
Occupations with potential exposure -

Acetic acid makers	Furnace starters
Acetylene workers	Garage mechanics
Airplane pilots	Gasoline engine testers
Ammonia makers	Heat treaters
Artificial gas workers	Lift truck operators
Automobile users	Metal oxide reducers
Blast furnace gas users	Methanol makers
Blast furnace workers	Nickel refiners
Boiler room workers	Nickel smelters
Brass founders	Organic chemical synthesizers
Brick burners	Oxalic acid makers
Carbon monoxide workers	Producer gas workers
Diesel engine operators	Steel makers
Dock workers	Tunnel attendants
Firemen	Water gas workers
Foundry workers	Zinc white makers

Toxicology -

Local effects - None.

Systemic effects - Combines with hemoglobin to form carboxyhemoglobin which interferes with oxygen carrying capacity of blood, resulting in a state of tissue hypoxia. Except for this, carbon monoxide is essentially a physiologically inert gas. It is probable that exposure to carbon monoxide gas does not produce a truly chronic type of intoxication but may, upon repeated intermittent exposures, produce repeated transient episodes of mild acute poisoning.

Medical Surveillance - Not recommended routinely.

Remarks - Special Diagnostic Test: Analysis of blood for carboxyhemoglobin. Persons with heart disease and other conditions causing hypoxia should not be employed in a CO environment. See TB MED 269.

References - Bell, M.A.: Subacute carbon monoxide poisoning. Arch. Environ. Health. 3:108, 1961.
Breysse, P.A.: Chronic carbon monoxide poisoning. Indust. Med. & Surg. 30:20, 1961.
Hofreuter, D.H.; Catcott, E.J., and Xintaras, C.: Carboxyhemoglobin in men exposed to carbon monoxide. Arch. Environ. Health. 4:81, 1962.
Katz, M.: Chronic carbon monoxide asphyxia, a common clinical entity. Canad. Med. Assoc. J. 78:182, 1958.
Pfrender, R.E.: Chronic carbon monoxide poisoning. A critical resume. Indust. Med. & Surg. 31:99, 1962.
Zorn, O. and Kruger, P.D.: The problem of chronic carbon monoxide poisoning. Indust. Med. & Surg. 29:580, 1960.

Carbon Tetrachloride (tetrachloromethane, perchloromethane)

TWA - 10 ppm (65 mg/m^3), 25 ppm C
TLV® - 10 ppm (65 mg/m^3)
Uses - Chemical intermediate, fumigant, fire extinguishing agent, solvent.
Occupations with potential exposure -

Carbon tetrachloride workers	Metal cleaners
Degreasers	Oil processors
Dry cleaners	Propellant makers
Fire extinguisher testers	Rotenone extractors
Firemen	Rubber makers
Freon makers	Solvent workers
Fur storage workers	Stainers
Grain fumigators	Type cleaners
Laboratory workers, chemical	Varnish removers
Lacquerers	Wax makers
Lacquer removers	

Toxicology -

Local effects - Repeated or prolonged contact with liquid can produce a dry, scaly, fissured dermatitis. Eye irritant.

Systemic effects - Excessive exposure will result initially in gastrointestinal irritation or central nervous system depression or both. After a few hours to several days following exposure, signs and symptoms of liver and kidney damage may develop. Nausea, vomiting, abdominal pain, diarrhea, enlarged and tender liver, jaundice, and abnormal liver function tests result from toxic hepatitis. Pulmonary and peripheral edema, elevated blood pressure, diminished urinary volume, abnormal urinalysis, coma, and death may be the consequence of acute renal failure. Headache, loss of appetite, and lassitude are characteristic of chronic exposure to carbon tetrachloride.

Medical Surveillance - Assessment of hepatic and renal function monthly.

Remarks - Special Diagnostic Test: Determination of carbon tetrachloride in blood.
Routes of Entry: Ingestion of liquid; inhalation of vapor. Percutaneous absorption of liquid leading to systemic intoxication is unlikely to occur. This substance should be eliminated from the

work environment whenever possible. Alcohol consumption increases susceptibility.

References - Lewis, C. E.: The toxicology of carbon tetrachloride. J. Occup. Med. 3:82, 1961.
Stewart, R. D.; Torkelson, T. R.; Hake, C. L., and Erley, D. S.: Infrared analysis of carbon tetrachloride and ethanol in blood. J. Lab. & Clin. Med. 56:148, 1960.
von Oettingen, W. F.: Poisoning, a Guide to Clinical Diagnosis and Treatment, 2nd ed. W. B. Saunders Co., Philadelphia, 1958.

Cellosolve: (ethylene glycol monoethyl ether, 2-ethoxyethanol)
Cellosolve acetate: (ethylene glycol monoethyl ether acetate, 2-ethoxyethyl acetate)
Methyl cellosolve: (ethylene glycol monomethyl ether, 2-methoxyethanol)
Methyl cellosolve acetate: (ethylene glycol monomethyl ether acetate, 2-methoxyethyl acetate)
Butyl cellosolve (ethylene glycol monobutyl ether, 2-butoxyethanol)

TWA - methyl cellosolve, 25 ppm (80 mg/m^3), Skin
methyl cellosolve acetate, 25 ppm (120 mg/m^3), Skin
Others not established.
TLV® - (recommended) Cellosolve - 200 ppm (740 mg/m^3)
Cellosolve Acetate - 100 ppm (540 mg/m^3)
Methyl Cellosolve - 25 ppm (80 mg/m^3)
Methyl Cellosolve Acetate - 25 ppm (120 mg/m^3)
Butyl Cellosolve - 50 ppm (240 mg/m^3)
Uses - Dope, stains, paints, lacquers, cleaners, enamels, film, varnish, waxes.
Occupations with potential exposure -

Cellophane sealers	Nitrocellulose makers
Cellosolve workers	Oil processors
Cleaning solution makers	Printers
Dope makers	Resin makers
Dry cleaners	Soap makers
Gum processors	Stainers
Dye makers	Textile dyers
Hydraulic fluid makers	Textile printers
Leather makers	Wax processors

Toxicology -

Local effects - Contact dermatitis from primary irritation. Vapors are mild irritants to conjunctiva and upper respiratory tract.

Systemic effects - Cellosolve, butyl cellosolve, and the cellosolve acetates have not produced systemic intoxication in industry. These compounds have been responsible for central nervous system depression, renal damage, and alterations in blood elements in certain laboratory animals. See Ethylene Glycol.

Medical Surveillance - None recommended.

References - Carpenter, C.P.; Pozzoni, U.C.; Weil, C.S.; Nair, S.H.; Keck, G.A.; Smyth, H.F., Jr.: The toxicity of butyl cellulose solvent. A.M.A. Arch. of Ind. Health. 14:114, 1956.
Zavon, M.R.: Methyl Cellosolve Intoxication, Am. Indust. Hyg. Assoc. J. 24:36, 1963.

Chloride of Lime (chlorinated lime, bleaching powder)

TWA - Not established.
TLV® - Not established.
Uses - Bleach.
Occupations with potential exposure -

Chloride of lime workers	Organic chemical synthesizers
Dyers	Sewage treaters
Laundry workers	Textile printers
Oil bleachers	Water treaters

Toxicology -

Local effects - The powder and its solutions have corrosive action on skin, eyes and mucous membranes and can produce conjunctivitis, blepharitis, corneal ulceration, gingivitis, and contact dermatitis.

Systemic effects - Dust is irritating to respiratory tract and can produce laryngitis and pulmonary edema.

Medical Surveillance - None recommended.

Remarks - May explode when heated above 100°C.

References - See General References (Appendix A).

Chlorine

TWA - 1 ppm (3 mg/m^3)
TLV® - 1 ppm (3 mg/m^3)
Uses - Bleaches, chlorinated solvents, DDT manufacture, disinfectants, dyes, phosgene manufacture, sewage treatment, water treatment.
Occupations with potential exposure -

Laundry workers	Submarine workers
Sewage treatment plant workers	Textile handlers
	Water treatment plant workers

Toxicology -

Local effects - Extreme irritation of skin, eyes, and mucous membranes; corrosion of teeth.

Systemic effects - Acute respiratory distress including cough, hemoptysis, chest pain, dyspnea, cyanosis. Later, tracheobronchitis, bronchopneumonia, and pulmonary edema may supervene.

Medical Surveillance - Pulmonary functions annually.

Remarks - Increased susceptibility to tuberculosis might indicate TB screening procedures.

References - Chasis, H.; Zapp, J.A.; Bannon, J.H.; Whittenberger, J.L.; Helm, J.; Doheny, J.J., and Macleod, C.M.: Chlorine accident in Brooklyn. Occup. Med. 4:152, 1947.
Joyner, R.E., and Duriel, E.G.: Accidental liquid chlorine spill in a rural community. J. Occup. Med. 4:152, 1962.

Chlorobenzene (phenyl chloride, monochlorobenzene, chlorobenzol)

TWA - 75 ppm (350 mg/m^3)
TLV® - 75 ppm (350 mg/m^3)
Uses - Lacquers, paints, explosives, varnish, dry cleaning, dyes, inks, polishes.
Occupations with potential exposure -

- Cellulose acetate workers
- Chlorobenzene workers
- Dry cleaners
- Dyers
- Ethyl cellulose workers
- Heat transfer workers
- Ink makers
- Lacquerers
- Lacquer makers
- Organic chemical synthesizers
- Paint workers
- Picric acid makers
- Resin makers
- Rubber makers
- Sulfur dye makers
- Varnish makers

Toxicology -

Local effects - Chlorinated benzenes are irritating to skin, conjunctiva, and mucous membranes of upper respiratory tract.

Systemic effects - Liver injury and cataracts have been reported with high exposures to certain of the chlorinated benzene compounds. Nephrotoxic to animals at high concentration.

Medical Surveillance - UA and SGOT annually. Vision screening followed by slit lamp examination if acuity decreased, annually.

References - See General References (Appendix A).

Chlorobromomethane

TWA - 200 ppm (1,050 mg/m^3)
TLV® - 200 ppm (1,050 mg/m^3)
Use - Fire extinguisher, chemical intermediate.
Occupations with potential exposure -

Extinguisher chargers
Firefighters
Pilots

Toxicology -

Local effects - Mild irritation of skin, eyes, mucosae. At higher concentrations pneumonitis.

Systemic effects - CNS depression with disturbances of vision and coordination; may proceed to narcosis and anesthetic death.

Medical Surveillance - SGOT annually. Vision screening followed by slit lamp examination if acuity decreased.

Remarks - Distinctive but agreeable odor at 400 ppm.

Reference - Patty, F.A., editor, Industrial Hygiene and Toxicology, Interscience Publishers, New York, 1967, II. 1271-1273.

Chloroform

TWA - 50 ppm (240 mg/m^3)
TLV® - 50 ppm (240 mg/m^3)
Uses - Anesthetic (limited), fumigant (limited), solvent.
Occupations with potential exposure -

Chemists	Medical laboratory workers
Degreasers	Pharmacists
Gluers	

Toxicology -

Local effects - Skin irritation varying from erythema to vesication. Chronic exposure may lead to dermatitis or aggravate existing conditions.

Systemic effects - Narcosis, anesthesia, CNS depression, cardiac sensitization. With chronic exposure, liver injury and less commonly renal injury.

Medical Surveillance - Exclude asthmatics, those with cardiac disease especially arrhythmias and those with chronic liver or kidney disease. No specific test, do liver function and renal function tests annually or more frequently if conditions require.

Remarks - Much more of a hazard than is usually indicated. If detectable by odor, concentration is too high.

Reference - Patty, F.A., editor, Industrial Hygiene and Toxicology, Interscience Publishers, New York, 1967, II. 1259-61.

Chromium compounds include chromic acid (chromic trioxide), chromates, and bichromates.

TWA - soluble salts, 0.5 mg/m^3
metal and insoluble salts, 1 mg/m^3
TLV® - 1 mg/m^3 (metal, insoluble salts)
0.5 mg/m^3 (soluble salts)
0.1 mg/m^3 (acid, chromates)
Uses - Alloys, printing, dyeing, manufacture of dyes, pigments, and explosives.
Occupations with potential exposure -

- Airplane sprayers
- Alloy makers
- Cement workers
- Ceramic workers
- Chromium platers
- Diesel locomotive repairmen
- Dye makers
- Dyers
- Electroplaters
- Explosive workers
- Furniture polishers
- Glass frosters
- Histology technicians
- Jewelers
- Laboratory workers
- Lithographers
- Metal cleaners
- Metal cutters
- Metal treaters
- Organic chemical synthesizers
- Painters
- Photographers
- Printers
- Pyrotechnic workers
- Smokeless powder makers
- Stainless steel workers
- Textile dyers
- Wood preservative workers
- Wood stainers

Toxicology -

Local effects - Contact with chromates or chromic acid can produce small, painless cutaneous ulcers as well as dermatitis from primary irritation or allergic hypersensitivity. Cutaneous allergy is not uncommon from hexavalent chromium compounds but is extremely rare from trivalent chromium compounds. Yellowish discoloration of teeth and tongue; perforation of nasal septum; conjunctivitis.

Systemic effects - Allergic bronchial asthma from chromium trioxide fume. Bronchogenic carcinoma has occurred at an abnormally high rate among chromate workers. The carcinogenic form of chromium has not been determined.

Medical Surveillance - Physical examination of skin and nasal septum accompanied by annual sputum cytology. Chest x-ray every 5 years and annually for employees over 40 years of age.

Remarks - Workers exposed only to chromic acid need not have annual sputum cytology. Epidemiologic studies report incidence of pulmonary cancer only in those workers who were exposed to both chromic acid and chromates. There are no convincing reports of occurrence of pulmonary cancer in workers exposed to only chromic acid.

References - Baetjer, A.M.: Pulmonary carcinoma in chromate workers. 1, A review of the literature and report of cases. A.M.A. Arch. Indust. Hyg. & Occup. Med. 2:487, 1950.
Bernhardt, H.J.: Chromate dermatitis; its natural history and treatment. A.M.A. Arch. Dermat. 76:13, 1957.
Division of Occupational Health, Public Health Service: Health of workers in chromate producing industry. Pub. Health Service Pub. No. 192. US Government Printing Office, Washington, DC, 1953.
Mancuso, T.F. and Hueper, W.C.: Occupational cancer and other health hazards in a chromate plant; a medical appraisal. 1, Lung cancer in chromate workers. Indust. Med. & Surg. 20:358, 1951.
Mancuso, T.F.: Occupational cancer and other health hazards in a chromate plant; a medical appraisal. 2, Clinical and toxicologic aspects. Indust. Med. & Surg. 20:393, 1951.

Coke Oven Emissions (coal tar pitch volatiles)

TWA - 0.2 mg/m^3
TLV® - 0.2 mg/m^3 (benzene soluble fraction)
Uses - Byproduct.
Occupations with potential exposure -

Artificial stone makers	Impregnated felt makers
Asbestos goods workers	Insecticide bomb makers
Asphalt workers	Insulation board makers
Battery box makers	Insulators
Battery workers, dry	Lens grinders
Boat builders	Linemen
Brick masons	Miners
Brick pressers	Painters
Brickyard workers	Paper conduit makers
Briquette makers	Pavers
Brush makers	Pipeline workers
Cable makers	Pipe pressers
Carpenters	Pitch workers
Coal tar still cleaners	Railroad track workers
Coal tar workers	Riveters
Coke oven workers	Road workers
Corkstone makers	Roofers
Creosoters	Roofing paper workers
Diesel engine engineers	Rope makers
Electric equipment makers	Rubber workers
Electricians	Shingle makers
Electrode makers	Shipyard workers
Electrometallurgic workers	Soap makers
Farmers	Smokeless fuel makers
Fishermen	Stokers
Flue cleaners	Tar paint makers
Fuel pitch workers	Tile pressers
Furnace men	Waterproof concrete workers
Gas house workers	Waterproofers
Glass blowers	Wood preservers

Toxicology -

Local Effects - Photosensitization may occur and is manifested by erythema, edema, burning, and subsequent hyperpigmentation of exposed areas. Other cutaneous effects include folliculitis, acne, and comedones; keratoses, papillomas, and squamous cell epitheliomas following years of exposure; contact dermatitis from

either primary irritation or allergic hypersensitivity; and conjunctivitis.

Systemic Effects - Overexposure to vapor produces anorexia, nausea, vomiting, and cough acutely. Leukemia and carcinomas of the skin, lung, bladder, and kidney have all been reported from inhalation or contact with the vapors and dusts of these compounds.

Medical Surveillance - Preplacement and annual medical examinations shall include: a comprehensive medical history, an occupational exposure history, a 14" X 17" posterior-anterior chest x-ray, a sputum cytology examination, a skin examination, a urinalysis with microscopic examination, pulmonary function testing (FEV_1, FVC), and an evaluation of the ability of the employee to wear a respirator.

Remarks - See NIOSH Criteria Document (Appendix D). Constituents include anthracene, phenanthrene, acridine, chrysene, pyrene.

References - Doll, R.: Occupational lung cancer; a review. Brit. J. Indust. Med. 16:181, 1959.
Fisher, R.E.W.: Skin cancer in tar workers. Trans. Assoc. Indust. Med. Officers. 3:315, 1954.
Lloyd, J.W.: Long-term mortality study of steelworkers V - Respiratory cancer in coke plant workers. J. Occup. Med. 13:53-68, 1971.
Redmond, C.K.; Ciocco, A.; Lloyd, J.W.; Rush, H.W.: Long-term mortality study of steelworkers VI - Mortality from malignant neoplasms among coke oven workers, J. Occup. Med. 14:621-29, 1972.

Cresol (cresylic acid, cresylol, hydroxytoluene, methyl phenol, oxytoluene, tricresol)

TWA - 5 ppm (22 mg/m^3), Skin
TLV® - 5 ppm (22 mg/m^3)
Uses - Manufacture of synthetic resins, explosives, paint, antiseptics, disinfectants, insecticides.
Occupations with potential exposure -

- Coal tar workers
- Cresol workers
- Cresylic acid makers
- Disinfectors
- Dye makers
- Explosive workers
- Flotation agent makers
- Flotation workers
- Foundry workers
- Glue workers
- Ink removers
- Insecticide workers
- Insulation enamel workers
- Oil additive makers
- Paint removers
- Photographic developer workers
- Pitch workers
- Resin makers
- Roofers
- Rubber makers
- Stainers
- Stain makers
- Surfactant makers
- Tar distillery workers
- Textile sizers
- Varnish remover makers
- Varnish removers
- Veterinarians
- Wool scourers

Toxicology -

Local effects - Cresol, a potent primary irritant, has a corrosive action on skin and mucous membranes. Intense irritation is produced upon contact with eye.

Systemic effects - Inhalation of vapor may cause pulmonary edema. Severe poisoning is followed by collapse, hypothermia, and death. Nonfatal poisoning may be followed by severe liver and kidney damage which appear after a period of apparent full recovery.

Medical Surveillance - SGOT and urinalysis annually.

Reference - Fairhall, L.T.: Industrial Toxicology. 2nd ed. Williams & Wilkins Co., Baltimore, 1957.

Cyclohexane

TWA - 300 ppm (1,050 mg/m^3)
TLV® - 300 ppm (1,050 mg/m^3)
Uses - Paint removers, plastics, solid fuels, varnish removers, waxes.
Occupations with potential exposure -

Benzene makers	Oil processors
Bitumen processors	Paint removers
Cellulose plastic makers	Plastic molders
Cycloparaffin workers	Resin makers
Fat processors	Rubber makers
Fungicide makers	Solid fuel makers, camp stove
Lacquerers	Varnish remover makers
Lacquer makers	Varnish removers
Nylon makers	Wax makers

Toxicology -

Local effects - Eye irritation and dry, scaly, fissured dermatitis can be produced by contact with liquid.

Systemic effects - Cycloparaffins are weakly narcotic; in high concentrations may produce headache, dizziness, nausea, vomiting, and unconsciousness.

Medical Surveillance - Usually none is required.

References - See General References (Appendix A).

Cyclohexanol

TWA - 50 ppm (200 mg/m^3)
TLV® - 50 ppm (200 mg/m^3)
Uses - Dry cleaning, textile cleaning, laundry and household preparations, leather lacquering, paint and varnish removers, component of polishes and rubber cements.
Occupations with potential exposure -

Dry cleaners	Painters
Laundry workers	Printers
Leather workers	

Toxicology -

Local effects - Irritating to mucosae. Eyes conjunctival congestion and irritation, lacrimator. Skin absorbed for systemic effects, locally necrosis, exudative ulceration and hyperkeratosis.

Systemic effects - Salivation, lethargy, incoordination, narcosis, convulsions; may be fatal. Non-specific toxic degeneration of brain, heart, liver and kidney tissues.

Medical Surveillance - SGOT, urine albumin annually.

Remarks - Dangerous by all routes, skin absorption a significant factor, use a substitute whenever possible.

Reference - Patty, F.A., editor, Industrial Hygiene and Toxicology, Interscience Publishers, New York, 1967, II. 1477-80.

Cyclohexanone

TWA - 50 ppm (200 mg/m^3)
TLV® - 50 ppm (200 mg/m^3)
Use - Solvent, chemical intermediate, dyes, resins, lacquers, shellac.
Occupations with potential exposure -

Dry cleaners	Painters
Enamelers	Photography laboratory workers
Lacquerers	Plastic workers
Leather workers	Printers
Mechanics	Textile workers

Toxicology -

Local effects - Irritating to conjunctivae and mucosae. Prolonged, repeated skin contact may lead to or aggravate dermatitis.

Systemic effects - Narcotic at high concentration.

Medical Surveillance - SGOT and urine albumin annually.

Remarks - With chronic, high exposure urinary organic sulfate and glucuronic acid are elevated.

Reference - Patty, F.A., editor, Industrial Hygiene and Toxicology, Interscience Publishers, New York, 1967, II. 1765-68.

o-Dichlorobenzene (1,2-dichlorobenzene)

TWA - 50 ppm (300 mg/m^3) C
TLV® - 50 ppm (300 mg/m^3)
Uses - DDT manufacture, drug manufacture, dry cleaning, dyes, inks, lacquers, paints, picric acid manufacture, rubber manufacture, varnish, asphalt, grease compounds, tars.
Occupations with potential exposure -

Asphalt makers	Greasers
Degreasers	Leather workers
Dry cleaners	Painters
Dyers	Resin & rubber workers
Exterminators	Tar removers
Fumigators	Wool processors

Toxicology -

Local effects - Chlorinated benzenes are irritating to skin, conjunctiva, and mucous membranes of upper respiratory tract.

Systemic effects - Studies of industrial populations exposed to o-dichlorobenzene reveal no significant systemic effects. Liver injury and cataracts have been reported with high exposures.

Medical Surveillance - Annual SGOT, and vision screening, followed by slit lamp examination if acuity decreased.

Reference - Hollingsworth, R. L.; Rowe, V. K.; Oyen, F.; Torkelson, T. R., and Adams, E. M.: Toxicity of o-dichlorobenzene; studies on animals and industrial experience. A.M.A. Arch. Indust. Health. 17:180, 1958.

1,2-Dichloroethylene (acetylene dichloride, vinylidene chloride)

TWA - 200 ppm (790 mg/m^3)
TLV® - 200 ppm (790 mg/m^3)
Uses - Dry cleaning, dyes, lacquers, degreasers.
Occupations with potential exposure -

Degreasers	Lacquerers
Dry cleaners	Painters
Dyers	

Toxicology -

Local effects - The solvent can act as primary irritant producing contact dermatitis. Vapor can cause irritation of mucous membranes of upper respiratory tract.

Systemic effects - Transient narcosis can result from inhalation of vapor. No chronic toxicity in man has been reported.

Medical Surveillance - None required.

Reference - McBirney, R. S.: Trichloroethylene and dichloroethylene poisoning. A.M.A. Arch. Indust. Hyg. & Occup. Med. 10:130, 1954.

Dinitrobenzene (Dinitrobenzol; meta-, ortho- and para-isomers)

TWA - 1 mg/m^3, Skin
TLV® - 0.15 ppm (1 mg/m^3)
Uses - Explosives manufacture, solvent, dyes.
Occupations with potential exposure -

Celluloid makers	Explosive users
Dinitrobenzene workers	Organic chemical synthesizers
Dye makers	Plastic makers
Explosive makers	

Toxicology -

Local effects - Dinitrobenzene is a primary skin irritant and sensitizer.

Systemic effects - Ortho-isomer is a powerful methemoglobin former and on prolonged exposure may lead to liver damage. It is readily absorbed through the intact skin and its vapors are *highly toxic. It is reported to cause a secondary* anemia on chronic absorption.

Medical Surveillance - Persons with significant impairment of oxygen-carrying ability should be excluded from employment. Monitor bimonthly for methemoglobin. SGOT and hematocrit annually, more frequently if conditions warrant. Dermatologic examination annually. Workers should examine each other for cyanosis at each shift's end.

Remarks - Special diagnostic tests: Analysis of urine for dinitrobenzene and blood for methemoglobin. See von Oettingen, 1958, and Stewart and Stolman, 1961.
Routes of entry: Percutaneous absorption of liquid; inhalation of vapor.
Highly toxic, use a substitute whenever possible.

References -
Beritic, T.: Two cases of meta-dinitrobenzene poisoning with unequal clinical response. Brit. J. Indust. Med. 13:114, 1956.
Stewart, C. P. and Stolman, A.: Toxicology; Mechanisms and Analytical Methods. Vol. 2, Academic Press, New York, 1961.
von Oettingen, W. F.: Poisoning, a Guide to Clinical Diagnosis and Treatment. 2nd ed. W. B. Saunders Co., Philadelphia, 1958.

Dinitrophenol

TWA - Not established.
TLV® - Not established.
Uses - Chemical synthesis, wood preservative, photographic developing.
Occupations with potential exposure -

Diaminophenol makers	Indicator makers, chemical
Dinitrophenol workers	Organic chemical synthesizers
Dye makers	Photographic developer makers
Explosive workers	Wood preservative workers
Herbicide workers	

Toxicology -

Local effects - Yellow staining of skin. Eczematous dermatitis due to either primary irritation or allergic hypersensitivity. Exfoliative dermatitis has occurred.

Systemic effects - Dinitrophenol blocks oxidative phosphorylation and thereby stimulates basal metabolism with resultant effects of anorexia, nausea, vomiting, sweating, thirst, dyspnea, excitement, tachycardia, and fever. Acidosis may develop. Central nervous system effects are those of stimulation followed by depression. There may be cataract formation, kidney or liver damage. Death may result from overwhelming exposure.

Medical Surveillance - Annual eye examination, Alk Phosph, and urinalysis to include urine for bile.

Remarks - Readily absorbed through the skin.

References - American Industrial Hygiene Association: 2,4-Dinitrophenol. Hygienic Guide Series. The Association, Detroit, 1958.
von Oettingen, W.F.: Poisoning, a Guide to Clinical Diagnosis and Treatment. 2nd ed. W.B. Saunders Co., Philadelphia, 1958.

Dinitrotoluene (dinitrotoluol, DNT)

TWA - 1.5 mg/m^3, Skin
TLV® - 1.5 mg/m^3
Uses - Dyes, explosives.
Occupations with potential exposure -

Dinitrotoluene workers	Explosive workers
Dye makers	Organic chemical synthesizers

Toxicology -

Local effects - Contact may produce allergic hypersensitization dermatitis.

Systemic effects - Symptoms and signs are similar to intoxication from trinitrotoluene. See Trinitrotoluene.

Medical Surveillance - Same as for Trinitrotoluene.

Remarks - Absorbed through intact skin.

References - See General References (Appendix A).

Dioxane (1,4-diethylene dioxide, diethylene ether)

TWA - 100 ppm (360 mg/m^3) Skin
TLV® - 100 ppm (360 mg/m^3)
Uses - Adhesive, dyes, paints, plastics.
Occupations with potential exposure -

Adhesive workers	Metal cleaners
Cement workers	Paint removers
Degreasers	Painters
Histology technicians	Printers
Lacquerers	Stainers

Toxicology -

Local effects - Irritation of eyes, nose and throat.

Systemic effects - Severe gastric symptoms. Liver necrosis and nephritis.

Medical Surveillance - SGOT and urine albumin annually; more frequently if conditions warrant.

Remarks - Routes of entry: Inhalation of vapor; percutaneous absorption of liquid.

References - See General References (Appendix A).

Ethyl Acetate (acetic ether, vinegar naphtha)

TWA - 400 ppm (1,400 mg/m^3)
TLV® - 400 ppm (1,400 mg/m^3)
Uses - Explosives manufacture, photographic film, varnishes.
Occupations with potential exposure -

Explosive workers	Photographic film workers
Lacquerers	Stainers
Letter workers	Varnishers
Leather workers	

Toxicology -

Local effects - Vapor may produce irritation of eyes, nose and throat. Concentrated solutions are capable of causing skin irritation. In rare instances, dermatitis from hypersensitivity to ethyl acetate may be encountered.

Systemic effects - Exhibits narcotic action through central nervous system depression. Prolonged inhalation may produce acute pulmonary edema.

Medical Surveillance - Dermatologic examination annually.

Reference - von Oettingen, W.F.: The aliphatic acids and their esters; toxicity and potential dangers; the saturated monobasic aliphatic acids and their esters. A.M.A. Arch. Indust. Health. 21:28, 1960.

Ethyl Alcohol

TWA - 1,000 ppm (1,900 mg/m^3)
TLV® - 1,000 ppm (1,900 mg/m^3)
Uses - Antifreeze, beverages, tissue fixatives, chemical intermediate.
Occupations with potential exposure -

Acetaldehyde makers	Motor fuel blenders
Acetic anhydride makers	Organic chemical sythesizers
Antifreeze makers	Rocket fuel handlers
Denatured alcohol makers	Rocket fuel makers
Distillers	Shellac processors
Dye makers	Solvent workers
Ethyl alcohol workers	Stainers
Explosive makers	Stain makers
Histology technicians	Thermometer makers, vapor pressure

Toxicology -

Local effects - Irritant to eyes and mucous membranes. Repeated contact can produce dry, scaly, fissured dermatitis.

Systemic effects - When inhaled in very high concentrations, a degree of alcoholic intoxication may be produced.

Medical Surveillance - None recommended.

References - Gonzales, T.A.; Vance, M.; Helpern, M., and Umberger, C.J.: Legal Medicine; Pathology and Toxicology. 2nd ed. Appleton-Century-Crofts, New York, 1954. Ch. 46.
Henson, E.V.: The toxicology of some aliphatic alcohols; part 2. J. Occup. Med. 2:497, 1960.

Ethylene Dichloride (1,2-dichloroethane, sym.-dichloroethane)

TWA - 50 ppm (200 mg/m^3), 100 ppm C
TLV® - 50 ppm (200 mg/m^3)
Uses - Dry cleaning, degreasing, paint removing, varnishes.
Occupations with potential exposure -

Degreasers	Painters
Dry cleaners	Varnishers
Dyers	Waxers
Exterminators	Wool processors
Fumigators	

Toxicology -

Local effects - Liquid and vapor are irritating to eyes. Irritation by vapor of upper respiratory tract may produce sneezing. Repeated contact with liquid can produce a dry, scaly, fissured dermatitis. Allergic contact dermatitis is rare.

Systemic effects - Vapor acts as narcotic in high concentrations and inhalation may produce headache, dizziness, loss of appetite, nausea, vomiting, epigastric pain, visual disturbances, loss of consciousness, and death. Vapor may irritate respiratory tract with production of cough. Liver damage has been suggested by some cases with enlargement of liver and low blood-sugar levels. Corneal opacities, as a systemic effect, have been observed only in dogs.

Medical Surveillance - Dermatologic examination annually. SGOT, urinary albumin, vision screening annually.

Remarks - Routes of Entry: Inhalation of vapor; percutaneous absorption of liquid.

Reference - Irish, D. D.: Common chlorinated aliphatic hydrocarbon solvents. Arch. Environ. Health. 4:320, 1962.

Ethylene Glycol (1,2-ethanediol, glycol alcohol, glycol)

TWA - Not established.
TLV® - 25 ppm (120 mg/m^3)
Uses - Antifreeze, brake fluid, cellophane manufacture, dyes, explosive manufacture, adhesives, inks, lacquers, paints, resins, waxes, stains.
Occupations with potential exposure -

Explosives makers	Metal cleaners
Garage workers	Painters
Lacquerers	Printers
Leather dyers	Waxers
Mechanics	Wood stainers

Toxicology -

Local effects - Liquid may irritate conjunctiva. Skin effects have not been reported.

Systemic effects - Ethylene glycol is a central nervous system depressant producing symptoms similar to ethyl alcohol intoxication. Cases of poisoning have generally followed ingestion of the compound. Inhalation of vapor is uncommon since liquid has high boiling point; however, episodes of unconsciousness, nystagmus, and lymphocytosis have been reported to follow inhalation. Death usually is the result of cardiac or renal failure. See Cellosolve.

Medical Surveillance - None required.

Remarks - Significant absorption through skin.

References - Morini, I.: Several cases of poisoning with commercial ethylene glycol. Minerva med. 1:72, 1954. (Indust. Hyg. Digest Abst. No. 210, February 1956)
Nadeau, G.; Cote, R., and Delaney, F. J.: Two cases of ethylene glycol poisoning. Canad. Med. Assoc. J. 70:69, 1954.
Troist, F. M.: Chronic intoxication by ethylene glycol vapour. Brit. J. Indust. Med. 7:65, 1950.

Ethylene Oxide (1,2-epoxyethane, oxirane, dimethylene oxide)

TWA - 50 ppm (90 mg/m^3)
TLV® - 50 ppm (90 mg/m^3)
Uses - Fumigant, sterilizer.
Occupations with potential exposure -

Acrylonitrile makers	Gasoline sweeteners
Butyl cellosolve makers	Grain elevator workers
Detergent makers	Organic chemical synthesizers
Disinfectant makers	Polyglycol makers
Ethanolamine makers	Polyoxirane makers
Ethylene glycol makers	Rocket fuel handlers
Ethylene oxide workers	Rocket fuel makers
Exterminators	Surfactant makers
Farm product fumigators	Textile fumigators
Foodstuff fumigators	Textile lubricant makers
Fumigant makers	Tobacco fumigators
Fungicide workers	

Toxicology -

Local Effects - Ethylene oxide liquid and gas are irritating to eyes and wet skin, but anhydrous liquid ethylene oxide does not cause primary injury to dry skin. Aqueous solutions near the 50 percent concentration are vesicants. Allergic eczematous dermatitis has also been reported. Ethylene oxide is absorbed by leather and rubber, and may produce belated irritation.

Systemic Effects - Gas is a pulmonary irritant and in high concentrations will produce pulmonary edema with cough, dyspnea, and respiratory distress. Systemic effects of headache, nausea, vomiting, and narcosis have been noted. Toxic effects may be due to glycols which are formed when ethylene oxide combines with water in the body.

Medical Surveillance - Usually none is required. Exposure is indicated by acute symptomatology.

Remarks - Vapor is highly flammable and subject to explosive decomposition.

References - Jacobson, K.H.; Hackley, E.B., and Feinsilver, L.: The toxicity of inhaled ethylene oxide and propylene oxide vapors. A.M.A. Arch. Indust. Health. 13:237, 1956.
Jacobson, K.H.: Industrial hygiene aspects of liquid propellants. Transactions, 22nd annual meeting, American Conference of Governmental Industrial Hygienists, 1960, p 30.
Royce, A. and Moore, W.K.S.: Occupational dermatitis caused by ethylene oxide. Brit. J. Indust. Med. 12:169, 1955.
Sexton, R.J. and Henson, E.V.: Dermatological injuries by ethylene oxide. J. Indust. Hyg. & Toxicol. 31:297, 1949.

Ethyl Ether (ethoxyethane, ether, diethyl ether, sulfuric ether, anesthetic ether, ethyl oxide, diethyl oxide)

TWA - 400 ppm (1,200 mg/m^3)
TLV® - 400 ppm (1,200 mg/m^3)
Uses - Anesthetic, collodion, dry cleaners, explosive manufacture, fumigants, waxes.
Occupations with potential exposure -

- Anesthetists
- Dry cleaners
- Explosives workers
- Fumigators
- Garage workers
- Medical technicians
- Nurses
- Physicians
- Waxers

Toxicology -

Local effects - Contact with liquid may produce a dry, scaly, fissured dermatitis.

Systemic effects - In acute exposure, there is a period of excitation followed by central nervous system depression or anesthesia. Pulmonary edema in rare instances may follow acute exposure.

Medical Surveillance - None required.

Remarks - Special Diagnostic Test: Analysis of blood for ether. See von Oettingen (Appendix A) (for evaluation of acute exposures).

References - See General References (Appendix A).

Fluorine and Compounds

TWA - Fluorine, 0.1 ppm (0.2 mg/m^3)
Fluoride, 2.5 mg/m^3
HF, 3 ppm (2 mg/m^3)
TLV® - Fluorine, 0.1 ppm (0.2 mg/m^3)
Fluoride, 2.5 mg/m^3
HF, 3 ppm (2 mg/m^3)
Uses - Rocket fuels, bleaches, dyes, fertilizers, fluorocarbons, adhesives, disinfectants, fungicides, paints, phosphorescent tubes, water treatment, wood preservatives.
Occupations with potential exposure -

- Bleachers
- Brass cleaners
- Construction workers
- Disinfectors
- Dyers
- Electroplaters
- Embalmers
- Etchers
- Exterminators
- Laundry workers
- Mothproofers
- Plastic workers
- Rocket fuel handlers
- Smelters
- Solderers
- Welders
- Wood preservers

Toxicology -

Local effects - Fluorine gas, anhydrous hydrofluoric acid and aqueous hydrofluoric acid are intense primary irritants of skin, eyes, and mucous membranes. Burns may be chemical or thermal. Chemical burns cause deep tissue destruction and may not become symptomatic until several hours after contact.

Systemic effects - Fluorine and hydrogen fluoride are pulmonary irritants and produce pulmonary edema. Inhalation of fluoride dust or fume may produce respiratory tract irritation manifested by chills, fever, dyspnea, and cough. Chronic toxicity from inhalation of fluoride as manifested by increased osseous radiopacity is seldom encountered.

Medical Surveillance - Chest x-ray every 3 years for those employees exposed longer than 10 years.

References - Derryberry, O.M.; Bartholomew, M.D., and Fleming, R.B.L.: Fluoride exposure and worker health; the health status of workers in a fertilizer manufacturing plant in relation to fluoride exposure. Arch. Environ. Health. 6:503, 1963.
Dieffenbacher, P.F. and Thompson, J.H.: Burns from exposure to anhydrous hydrofluoric acid. J. Occup. Med. 4:325, 1962.
Pattison, F.L.M.: Toxic Aliphatic Fluorine Compounds, Elsevier Publishing Co., Amsterdam and Princeton, NJ., 1959.
Princi, F.: Fluorides; a critical review. 3, The effects on man of the absorption of fluoride. J. Occup. Med. 2:92, 1960.

Freon® - Freon-11, fluorotrichloromethane
Freon-12, dichlorodifluoromethane
Freon-12B2, difluorodibromomethane
Freon-13, monochlorotriflucromethane
Freon-13B1, trifluoromonobromomethane
Freon-14, tetrafluoromethane
Freon-21, dichlorombnofluoromethane
Freon-22, monochlorodifluoromethane
Freon-23, trifluoromethane
Freon-112, tetrachlorodifluoroethane
Freon-113, trichlorotrifluoroethane
Freon-113B2, dibromomonochlorotrifluoroethane
Freon-114, dichlorotetrafluoroethane
Freon-114B2, dibromotetrafluoroethane
Freon-115, monochloropentafluoroethane
Freon-C318, octafluorocyclobutane

TWA - Freon-11, 1,000 ppm (5,600 mg/m^3)
Freon-12, 1,000 ppm (4,950 mg/m^3)
Freon-12B2, 100 ppm (860 mg/m^3)
Freon-13, Not established
Freon-13B1, 1,000 ppm (6,100 mg/m^3)
Freon-14, Not established
Freon-21, 1,000 ppm (4,200 mg/m^3)
Freon-22, Not established
Freon-23, Not established
Freon-112, 500 ppm (4,170 mg/m^3)
Freon-113, 1,000 ppm (7,600 mg/m^3)
Freon-113B2, Not established
Freon-114, 1,000 ppm (7,000 mg/m^3)
Freon-114B2, Not established
Freon-115, Not established
Freon-C318, Not established

TLV® - Recommended Threshold Limit Values:
Freon-11, 1,000 ppm (5,600 mg/m^3)
Freon-12, 1,000 ppm (4,950 mg/m^3)
Freon-12B2, 100 ppm (860 mg/m^3)
Freon-13B1, 1,000 ppm (6,100 mg/m^3)
Freon-21, 1,000 ppm (4,200 mg/m^3)
Freon-112 (tentative), 500 ppm (4,170 mg/m^3)
Freon-113, 1,000 ppm (7,600 mg/m^3)
Freon-114, 1,000 ppm (7,000 mg/m^3)

Freon® is a registered trademark for fluorocarbons of E.I. du Pont de Nemours & Co. Use of trademarked names does not imply endorsement by the US Army, but is used only to assist in identification of a specific compound.

Uses - Propellants, refrigerants, fire extinguishing agents.
Occupations with potential exposure:

- Aerosol bomb workers
- Ceramic mold makers
- Fire extinguisher workers
- Freon workers
- Heat transfer workers
- Metal conditioners
- Plastic makers
- Pressurized food makers
- Refrigerant workers
- Rocket fuel makers
- Solvent workers

Toxicology -

Local effects - These fluorinated hydrocarbons may produce very mild irritation of the upper respiratory tract. If halogen-containing compounds, such as the Freons, come into contact with an open flame or hot metal, the decomposition products of hydrogen chloride, hydrogen fluoride, phosgene, sulfur dioxide, chlorine and others may cause severe irritative effects and ultimately the death of the exposed individual.

Systemic effects - Certain of these Freons may produce mild central nervous system depression. Systemic effect may be due in part to displacement of air, with resultant hypoxia. Some of these compounds sensitize the myocardium to endogenously-produced epinephrine resulting in a wide gamut of rhythm disturbances occasionally resulting in sudden death of highly exposed workers.

Medical Surveillance - None recommended.

Remarks - Persons with cardiac arrythmias should be employed with caution in some Freon (i.e., Freon-11, 12, 114, 142B) environments.

References - Azar, A.: Cardiovascular Effects of Fluorocarbon Exposure. Second Conference on Environmental Toxicology. Wright-Patterson Air Force Base. 1971.
Pattison, F.L.M.: Toxic Aliphatic Fluorine Compounds. Elsevier Publishing Co., Amsterdam, and Princeton, N.J., 1959.
Reinhardt, C.F., et. al.: Cardiac Arrhythmias and Aerosol "Sniffing". Arch. Environ. Health. 22:265, 1971.

Gasoline (petrol, motor spirits)

TWA - Not established.
TLV® - Determined by aromatic hydrocarbon content.
Uses - Fuel, diluent, and solvent.
Occupations with potential exposure - Gasoline is used as a fuel, diluent, and solvent in numerous occupations throughout various industries.

Toxicology -

Local effects - Gasoline is irritating to skin, conjunctiva, and mucous membranes of upper respiratory tract.

Systemic effects - Exposure to low concentrations of vapor may produce symptoms similar to ethyl alcohol intoxication, including flushing of face, staggering gait, slurred speech, and mental confusion. Higher concentrations may result in unconsciousness, coma, and death. Ingestion of liquid often results in aspiration with a pneumonitis similar to that seen in kerosine intoxication. Symptoms of gastrointestinal irritation may also occur. The existence of chronic poisoning has been questioned. The possibility of blood alterations developing from absorption of aromatic hydrocarbons in gasoline should be considered.

Medical Surveillance - None required.

References - See General References (Appendix A).

Heptane (n-heptane)

TWA - 500 ppm (2,000 mg/m^3)
TLV® - 500 ppm (2,000 mg/m^3)
Uses - Fuel, degreasers, paint removers.
Occupations with potential exposure -

Degreasers
Mechanics
Paint removers

Toxicology -

Local effects - Prolonged or repeated contact can lead to dry, scaling, fissured dermatitis.

Systemic effects - Heptane, in concentrations of 10,000 to 15,000 ppm (1 to 1.5 percent) produces narcosis in mice within 30 to 60 minutes. At higher concentrations, 15,000 to 20,000 ppm (1.5 to 2 percent), a 30- to 60-minute exposure caused convulsions and death in mice. Slight vertigo developed in men exposed for 6 minutes to 1000 ppm (0.1 percent) and for 4 minutes to 2000 ppm (0.2 percent) A 4-minute exposure to 5000 ppm (0.5 percent) heptane caused marked vertigo, inability to walk a straight line, hilarity and incoordination. It is significant that these signs and symptoms of systemic effects were produced in the absence of evidence or complaints of mucous membrane irritation. A 15-minute exposure to heptane at this concentration produced a state of intoxication characterized by uncontrolled hilarity in some individuals and in others a stupor lasting for 30 minutes after the exposure. These symptoms were frequently intensified or first noticed at the moment of entry into an uncontaminated atmosphere. These individuals also complained of loss of appetite, slight nausea, and a taste resembling gasoline for several hours after exposure to heptane.

Medical Surveillance - None required.

References - See General References (Appendix A).

Hexane (n-Hexane)

TWA - 500 ppm (1,800 mg/m^3)
TLV® - 500 ppm (1,800 mg/m^3)
Uses - Fuel, degreasers, paint removers.
Occupations with potential exposure -

- Degreasers
- Mechanics
- Paint removers

Toxicology -

Local effects - Mildly irritating to eyes and mucosae. Repeated or prolonged exposures will cause defatting of skin leading to dermatitis.

Systemic effects - Narcosis is produced in mice at concentrations of approximately 30,000 ppm (3 percent); convulsions and death resulted from exposures of equal duration to 35,000 to 40,000 ppm (3.5 to 4 percent). In man, 2000 ppm (0.2 percent) hexane produced no symptoms during a 10-minute exposure, whereas 5000 ppm (0.5 percent) caused dizziness and a sensation of giddiness.

Medical Surveillance - None required.

References - See General References (Appendix A).

Hydrazine (hydrazine base, diamine)

TWA - 1 ppm (1.3 mg/m^3) Skin
TLV® - 1 ppm (1.3 mg/m^3)
Uses - Chemical intermediate, rocket fuel.
Occupations with potential exposure -

Anticorrosion additive workers	Jet fuel handlers
Antioxidant workers	Jet fuel makers
Boiler operators	Oxygen scavenger makers
Chlorine scavenger makers	Rocket fuel handlers
Explosive makers	Rocket fuel makers
Hydraulic fluid workers	Textile dyers, acrylic and vinyl
Hydrazine workers	Vat dye makers
	Water treaters

Toxicology -

Local Effects - Contact of this hygroscopic liquid with skin and eyes produces penetrating burns. Contact with vapor results in eczematous dermatitis from either primary irritation or allergic hypersensitivity. Irritation of eyes and nose by high concentrations is so intense as to compel workers to leave the area usually before lower respiratory tract suffers damage.

Systemic effects - Low grade exposure produces headache, nausea, and dizziness. Bronchitis and pneumonitis may result if early irritative symptoms are not heeded. In animal experiments, hydrazine has produced central nervous system symptoms of excitement and convulsions, fatty necrosis of liver, nephritis, hemolytic anemia, hypoglycemia, and hypotension.

Medical Surveillance - SGOT, SGPT, Alk Phosph, CBC, BUN, Creatinine, UA and EEG annually. Complete physical examination on an age-related basis.

Remarks - Anti-tubercular and anti-hypertensive therapy may increase susceptibility.

References - Evans, D.M.: Two cases of hydrazine hydrate dermatitis without systemic intoxication. Brit. J. Indust. Med. 16:126, 1959.
Jacobson, K.H.: Industrial hygiene aspects of liquid propellants. In Transactions, 22nd annual meeting, American Conference of Governmental Industrial Hygienists, 1960.
Krop, S.: Toxicity of hydrazine. A review. A.M.A. Arch. Indust. Hyg. & Occup. Med. 9:199, 1954.
Office of Director, Defense Research and Engineering, Department of Defense: The Handling and Storage of Liquid Propellants. U.S. Government Printing Office, Washington, D.C., 1961.

Hydrogen Chloride

TWA - 5 ppm (7 mg/m^3), C
TLV® - 5 ppm (7 mg/m^3)(ceiling)
Uses - Metal pickling, chemical intermediate.
Occupations with potential exposure -

Alkyl chloride makers	Metal cleaners
Bleachers	Ore reduction workers
Boiler scale removers	Organic chemical synthesizers
Bronzers	Photoengravers
Chloride makers	Pigment workers
Chloroprene makers	Plastic workers
Dye makers	Pottery workers
Electroplaters	Rubber makers
Enamelers	Silica gel makers
Food processors	Tannery workers
Galvanizers	Tantalum ore refiners
Glass finishers	Tetraethyl lead makers
Glass mixers	Textile workers
Glue makers	Tin ore refiners
Hydrogen chloride workers	Veterinarians
Jewelers	Vinyl chloride makers
Lithographers	Wire annealers

Toxicology -

Local effects - Hydrochloric acid and high concentrations of hydrogen chloride gas are highly irritating to eyes, skin, and mucous membranes. Discoloration of teeth and tooth decay have been noted from exposure to low concentrations of gas.

Systemic effects - Pulmonary edema is possible, but usually the cough and choking sensation from intense irritation of upper respiratory tract compel worker to leave the area.

Medical Surveillance - Dental examination for tooth erosion triennially.

References - Queries and Minor Notes: Effects of hydrochloric acid fumes. J. Am. Med. Assoc. 131:1182, 1946.
Thiele, E.: Fatal poisoning from use of hydrochloric acid in a confined space. Zentralbl. Arbeitsmed. u. Arbeitsschutz. 3:146, 1953. (Indust. Hyg. Digest, Abst. No. 387, April 1954.)

Hydrogen Cyanide

TWA - 10 ppm (11 mg/m^3), Skin
TLV® - 10 ppm (11 mg/m^3)
Uses - Fumigant, used in electroplating, chemical intermediate.
Occupations with potential exposure -

- Acid dippers
- Acrylate makers
- Acrylonitrile makers
- Adiponitrile makers
- Aircraft workers
- Ammonium salt makers
- Art printing workers
- Blast furnace workers
- Bronzers
- Browners, gun barrel
- Cadmium platers
- Case hardeners
- Cellulose product treaters
- Coal tar distillery workers
- Cyanide workers
- Cyanogen makers
- Dye makers
- Electroplaters
- Exterminators
- Fulminate mixers
- Fumigators
- Gas purifiers
- Gas workers, illuminating
- Gilders
- Gold refiners
- Heat treaters
- Hexamethylenediamine makers
- Hydrocyanic acid makers
- Hydrogen cyanide makers
- Jewelers
- Metal cleaners
- Metal polishers
- Methacrylate makers
- Mirror silverers
- Mordanters
- Organic chemical synthesizers
- Phosphoric acid makers
- Photoengravers
- Plastic workers
- Rubber makers
- Silver extractors
- Silver refiners
- Solderers
- Steel carburizers
- Tannery workers
- Temperers
- Textile printers
- Tree sprayers
- Zinc platers
- Zinc workers

Toxicology -

Local effects - None.

Systemic effects - Symptoms are caused by chemical asphyxia, that is, inhibition of cellular oxidative processes. Acute and subacute symptoms include headache, nausea, vomiting, shortness of breath, irritation of throat, convulsions, respiratory paralysis, coma, and death. Whether chronic toxicity occurs is debatable.

Medical Surveillance - None recommended.

References - Amdur, M.L.: Accidental exposure to acetonitrile; a clinical study. J. Occup. Med. 1:627, 1959.
Elkins, H.B.: The Chemistry of Industrial Toxicology. 2nd ed. John Wiley and Sons, New York, 1959.
Wolfsie, J.H. and Shaffer, C.B.: Hydrogen cyanide; hazards, toxicology, prevention and management of poisoning. J. Occup. Med. 1:281, 1959.

Hydrogen Sulfide

TWA - Not established.
TLV® - 10 ppm (15 mg/m^3)
Uses - Byproduct.
Occupations with potential exposure -

- Blast furnace workers
- Cable splicers
- Caisson workers
- Cistern cleaners
- Dye makers
- Gold ore workers
- Heavy metal precipitators
- Hydrochloric acid purifiers
- Hydrogen sulfide workers
- Laboratory workers, chemical
- Lead removers
- Lithographers
- Manholes, workers in
- Natural gas makers
- Petroleum refinery workers
- Phosphate purifiers
- Photoengravers
- Pyrite burners
- Septic tank cleaners
- Sewage treatment plant workers
- Sewer workers
- Sheep dippers
- Sulfuric acid purifiers
- Sulfur makers
- Tannery workers
- Textile printers
- Tunnel workers
- Vulcanizers
- Well diggers

Toxicology -

Local effects - Irritating to eyes and to mucous membranes of nose and throat.

Systemic effects - Hydrogen sulfide is an asphyxiant because of its ability to paralyze the respiratory centers of brain with resultant cessation of respiration. Unless death occurs during the period of respiratory paralysis, recovery is usually complete. An exception to this tendency toward complete recovery is occasionally seen when period of hypoxia produces permanent brain injury. Prolonged exposure to moderately high concentrations of hydrogen sulfide may irritate tissues of the respiratory tract sufficiently to produce pneumonitis or pulmonary edema. Excessive exposure to concentrations of this order of magnitude may also be attended by such symptoms as headache, gastrointestinal disturbances, dizziness, chest pain, and cough.

Medical Surveillance - None recommended.

Remarks - Hydrogen sulfide is detectable by odor at 0.2 ppm.

References -
Ahlborg, G.: Hydrogen sulfide poisoning in shale oil industry. A.M.A. Arch. Indust. Hyg. & Occup. Med. 3:247, 1951.
Freireich, A.W.: Hydrogen sulfide poisoning. Report of two cases, one with fatal outcome from associated mechanical asphyxia. Am. J. Path. 22:147, 1946.
Haggard, H.W.: The toxicology of hydrogen sulfide. J. Indust. Hyg. 7:113, 1925.
Milby, T.H.: Hydrogen sulfide intoxication; review of the literature and report of unusual accident resulting in two cases of nonfatal poisoning. J. Occup. Med. 4:431, 1962.

AD-A063 716 ARMY ENVIRONMENTAL HYGIENE AGENCY ABERDEEN PROVING GR--ETC F/G 6/5
MEDICAL SURVEILLANCE GUIDE (GUIDE FOR JOB-RELATED EXAMINATIONS)--ETC(U)
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Iron Compounds

TWA - oxide, 10 mg/m^3
TLV® - soluble salts, 1 mg/m^3
oxide, 10 mg/m^3
Uses - Steel manufacture.
Occupations with potential exposure -

- Arc cutters
- Arc welders
- Flame cutters
- Foundry workers
- Furnace operators
- Iron workers
- Metalizer
- Oxyacetylene cutters
- Steam welders
- Stainless steel makers
- Welders

Toxicology -

Local effects - Ferric chloride, ferric ferrocyanide, and ferric sesquichloride are known skin sensitizers.

Systemic Effects - Iron salts may irritate respiratory tract. Iron oxide, when inhaled, may produce roentgenographic changes in lungs which resemble silicosis. This condition is referred to as siderosis and is thought to be benign. Iron carbonyl is a liquid with highly toxic vapors which, upon inhalation, may produce extreme pulmonary irritation.

Medical Surveillance - None recommended.

References - See General References (Appendix A).

Isobutyl Alcohol

TWA - 100 ppm (300 mg/m^3)
TLV® - 100 ppm (300 mg/m^3)
Uses - Lacquers, paint removers, cleaners, hydraulic fluids.
Occupations with potential exposure -

Dry cleaners	Metal cleaners
Hydraulic fluid workers	Paint removers
Lacquer removers	

Toxicology -

Local effects - Slightly irritating to skin; may aggravate existing dermatitis. Irritating to eyes, nose and throat.

Systemic effects - At high concentrations inebriation, incoordination; may progress to narcosis and death if exposure prolonged.

Medical Surveillance - None required.

References - See General References (Appendix A).

Isophorone

TWA - 25 ppm (140 mg/m^3)
TLV® - 25 ppm (140 mg/m^3)
Uses - Oil, fat, gum, resin solvent, lacquer, nitrocellulose and vinyl solvent, chemical intermediate.
Occupations with potential exposure -

Cleaners	Lacquerers
Degreasers	Nitrocellulose workers

Toxicology -

Local effects - Irritating to eyes, nose and throat.

Systemic effects - Lung irritant, nephrotoxic.

Medical Surveillance - Urine albumin annually. Exclude asthmatics from employment. Persons with chronic lung disease are adversely affected.

References - See General References (Appendix A).

Isopropyl Acetate

TWA - 250 ppm (950 mg/m^3)
TLV® - 250 ppm (950 mg/m^3)
Uses - Dope, lacquers, resins, waxes.
Occupations with potential exposure -

Dope processors	Oil processors
Fat processors	Organic chemical synthesizers
Isopropyl acetate workers	Plastic makers
Lacquerers	Resin makers
Leather makers, artificial	Solvent workers
Nitrocellulose makers	Wax makers

Toxicology -

Local effects - Vapor can be irritating to conjunctiva and to mucous membranes of upper respiratory tract.

Systemic effects - No ill effects from use of isopropyl acetate in industry have been recorded. Vapors can produce central nervous system depression following excessive exposure.

Medical Surveillance - None required.

References - See General References (Appendix A).

Isopropyl Alcohol

TWA - 400 ppm (980 mg/m^3)
TLV® - 400 ppm (980 mg/m^3)
Uses - Antifreeze, deicers, inks, lacquers, varnishes, stains, rocket fuels.
Occupations with potential exposure -

Garage workers	Printers
Lacquerers	Rocket fuel handlers
Nurses	Stainers
Physicians	Varnishers

Toxicology -

Local effects - Inhalation of vapor can produce mild irritation of conjunctiva and mucous membranes of upper respiratory tract.

Systemic effects - No industrial poisoning has been recorded. Isopropyl alcohol is potentially narcotic.

Medical Surveillance - Not required.

Remarks - Special Diagnostic Tests: Analysis for isopropyl alcohol and acetone in blood, urine and body tissues. See Patty.

References - Henson, E.V.: The toxicology of some aliphatic alcohols; part 2. J. Occup. Med. 2:497, 1960.
Patty, F.A., editor, Industrial Hygiene and Toxicology. 1st ed., Vol 2. Interscience Publishers, New York, 1949.

Kerosine (kerosene)

TWA - Not established.
TLV® - Not established.
Uses - Fuel, solvent.
Occupations with potential exposure -

- Farmers
- Garage workers
- Heating fuel handlers
- Insecticide workers
- Jet fuel handlers
- Jet fuel makers
- Kerosine workers
- Metal cleaners
- Petroleum refinery workers
- Rocket fuel handlers
- Rocket fuel makers

Toxicology -

Local effects - Contact with liquid may produce primary skin irritation.

Systemic effects - Toxic manifestations include central nervous system depression and pneumonia. Pulmonary effects may follow aspiration of liquid accidentally ingested.

Medical Surveillance - None required.

References - See General References (Appendix A).

Ketones - Commonly used ketone solvents include -
acetone (dimethyl ketone, beta-ketopropane, pyroacetic ether)
butanone (methyl ethyl-ketone, MEK, ethyl methyl ketone)
pentanone (methyl propyl ketone, MPK, ethyl acetone)
methyl butyl ketone (propyl acetone)

TWA - See specific compound.
TLV® - See specific compound.
Uses - Solvents.
Occupations with potential exposure -

Bronzers	Pesticide makers
Cleaning compound makers	Printers
Equipment cleaners	Rubber cement workers
Explosive makers	Solvent workers
Lacquerers	Stainers
Metal cleaners	Textile makers
Painters	Varnish workers

Toxicology -

Local effects - These solvents can produce a dry, scaly, and fissured dermatitis after repeated exposure. High vapor concentrations may irritate conjunctiva and mucous membranes of nose and throat.

Systemic effects - In high concentrations, narcosis is produced with symptoms of headache, nausea, vomiting, dizziness, incoordination, and unconsciousness.

Medical Surveillance - None recommended.

References - Henson, E.V.: Toxicology of some aliphatic ketones. J. Occup. Med. 1:607, 1959.
von Oettingen, W.F.: Poisoning, a Guide to Clinical Diagnosis and Treatment. 2nd ed. W.B. Saunders Co., Philadelphia, 1958.

Lead (Inorganic)

TWA - 0.2 mg/m^3
TLV® - 0.15 mg/m^3
Uses - Alloys, solder, bullets, casting of type, paint.
Occupations with potential exposure -

Accuracy testing	Melting
Coating materials	Pouring metals
Cutting materials	Power sanding (painted surfaces)
Filling (ammunition)	Proof testing
Firing weapons	Soldering
Grinding (painted surfaces)	Spray painting
Leading-in (vehicle body repair)	Welding

Toxicology -

Systemic effects - Lead poisoning in industry almost always results from inhalation of lead-containing dust or lead fume. Signs and symptoms of lead poisoning may include abdominal pain (colic) with tenderness, constipation, headache, weakness, muscular aches or cramps, loss of appetite, nausea, vomiting, weight loss, anemia with pallor, and a lead line of the gingival margin. Lead palsy and lead encephalopathy resulting from industrial exposure occur infrequently.

Medical Surveillance - Annual urinary lead. If elevated, employee should be removed from exposure and monthly urinary lead determinations accomplished until levels return to normal.

Remarks - See NIOSH Criteria Document (Appendix D). Anemic individuals should not be employed in a lead environment.

References - Kehoe, R.A.: A critical appraisal of current practices in the clinical diagnosis of lead intoxication. Indust. Med. & Surg. 20:253, 1951.
Kehoe, R.A.: Lead poisoning. In Cecil, R.L. and Loeb, R.F. (editors): Textbook of Medicine. 10th ed. W.B. Saunders Co., Philadelphia, 1959.
Skinner, H.L.,Jr.: The lead problem - An outline of current knowledge and opinion. J. Occup. Med. 3:429, 1961.
Various Authors: Lead Symposium, February 25-27, 1963. University of Cincinnati, Cincinnati, Ohio, 1963.

Mercury and Compounds (metallic mercury; quicksilver, hydrargyrum)

TWA - 1 mg/10 m^3
TLV® - Inorganic - 0.05 mg/m^3
Organic - 0.01 mg/m^3
Uses - Electric apparatus, industrial control instruments, agricultural and industrial poisons, pharmaceutical and dental preparations.
Occupations with potential exposure -

Accuracy testing	Filling instruments
Analyzing	Filtering
Cleaning	Maintenance
Clinical laboratories	Pesticide workers
Clock testing	Repairing instruments
Dental workers	Testing materials

Toxicology -

Local effects - Certain mercurial compounds are primary skin and mucous membrane irritants. Allergic hypersensitization is seen less frequently.

Systemic effects - Acute severe exposures may produce abdominal pain, vomiting, diarrhea, gingivitis, pneumonitis, renal damage, and circulatory or respiratory failure. Chronic excessive exposure to many inorganic mercury compounds may result in one or more of the three classical signs of gingivitis, tremor, and emotional instability. Headaches, insomnia, digestive disturbances, renal damage, hearing impairment, restriction of visual fields, and crystalline lens discoloration have also been described. Intoxication resulting from exposure to certain organic mercurials, such as diethyl mercury and methyl mercury iodide, can often be differentiated from inorganic mercury intoxication. This condition is characterized by ataxia, tremor, dysarthria, impaired hearing, paresthesias, emotional instability, and restriction of visual fields. Permanent sequelae may occur following either acute or chronic intoxication from inorganic mercurial compounds.

Medical Surveillance - Analysis of urine for mercury annually. If elevated, employee should be removed from exposure and monthly determinations made until urinary levels are normal.

Remarks - See NIOSH Criteria Document (Appendix D). Routes of entry: Inhalation of vapor. Percutaneous absorption of metal and organic compounds.

References - Battigelli, M.C.: Mercury toxicity from industrial exposure. A critical review of the literature. J. Occup. Med. 2:337, 1960.
Goldwater, L.J.; Jacobs, M.B., and Ladd, A.C.: Absorption and excretion of mercury in man. 1, Relationship of mercury in blood and urine. Arch. Environ. Health. 5:537, 1962.
Kurland, L.T.; Faro, S.N., and Siedler, H.: Minamata disease; the outbreak of a neurologic disorder in Minamata, Japan, and its relationship to the ingestion of seafood contaminated by mercuric compounds. World Neurology. 1:370, 1960.

Methyl Acetate

TWA - 200 ppm (610 mg/m^3)
TLV® - 200 ppm (610 mg/m^3)
Uses - Plasticizer.
Occupations with potential exposure -

Plastic makers

Toxicology -

Local effects - Irritating to eyes, upper and lower respiratory tract.

Systemic effects - Narcosis. May be fatal at high concentration. Simulates methyl alcohol in ocular toxicity.

Medical Surveillance - Exclude asthmatics and those with chronic lung conditions. Visual screening semiannually.

Remarks - Fire hazard. Use substitute whenever possible.

References - See General References (Appendix A).

Methyl Alcohol (methanol, carbinol, wood alcohol, wood spirit)

TWA - 200 ppm (260 mg/m^3)
TLV® - 200 ppm (260 mg/m^3)
Uses - Lacquers, stains, industrial solvent, enamels, antifreeze, chemical intermediate.
Occupations with potential exposure -

Adhesive workers	Methyl acrylate makers
Alcohol lamp users	Methyl alcohol workers
Aldehyde pumpmen	Methylamine makers
Antifreeze workers	Methylation workers
Art glass workers	Methyl bromide makers
Automobile painters	Methyl chloride makers
Aviation fuel handlers	Methyl methacrylate makers
Bookbinders	Millinary workers
Bronzers	Motor fuel blenders
Denatured alcohol workers	Organic chemical synthesizers
Dry cleaners	Painters
Dye makers	Paint remover workers
Dyers	Photoengravers
Ester makers	Resin makers
Explosive workers	Rocket fuel handlers
Feather workers	Rocket fuel makers
Formaldehyde makers	Rubber shoe cementers
Foundry workers	Rubber workers
Furniture polishers	Shellackers
Gilders	Shoe finishers
Glass makers	Shoe stitchers
Hectograph operators	Solvent workers
Jet fuel workers	Textile printers
Lacquerers	Type cleaners
Lasters	Upholsterers
Leather workers	Varnish workers
Lithographers	Vulcanizers
Metal polishers	Wood stainers

Toxicology -

Local effects - Contact with liquid can produce a dry, scaly, fissured dermatitis. Both liquid and vapor irritate mucous membranes of eyes, nose, and throat.

Systemic effects - Toxic effect of methyl alcohol on optic nerve is mediated through its oxidation product, formaldehyde, and may result in blurring of vision, pain in eyes, loss

of central vision, or blindness. Other central nervous system effects result from narcosis and include headache, nausea, giddiness, and loss of consciousness. Another oxidation product, formic acid, may produce acidosis. Severe intoxication may produce kidney and liver damage. Inhalation of vapor may irritate respiratory tract and produce bronchitis or bronchopneumonia.

Medical Surveillance - Vision screening with funduscopic examination, SGOT, and urinalysis are the procedures of choice. Frequency of examination should be determined by degree of exposure. Continuous exposure to levels greater than one-third of the TLV would require examination at least at monthly intervals.

References - Keeney, A.H. and Mellinkoff, S.M.: Methyl alcohol poisoning. Ann. Int. Med. 34:331, 1951.
von Oettingen, W.F.: Poisoning, a Guide to Clinical Diagnosis and Treatment. 2nd Ed. W.B. Saunders Co., Philadelphia, 1958.

Methyl n-amyl Ketone (2-Heptanone)

TWA - 100 ppm (465 mg/m^3)
TLV® - 100 ppm (465 mg/m^3)
Uses - Dry cleaners, degreasers, spot removers, essences.
Occupations with potential exposure -

Degreasers	Metal cleaners
Dry cleaners	Textile workers

Toxicology -

Local effects - Irritating to eyes, nose and throat.

Systemic effects - Narcosis at high concentration.

Medical Surveillance - None required.

Remarks - For cardiac patients, especially those with arrhythmias, treat the TLV as a C value.

References - See General References (Appendix A).

Methyl Bisphenyl Isocyanate (Diphenylmethane isocyanate, MDI)

TWA - 0.02 ppm (0.2 mg/m^3), C
TLV® - 0.02 ppm (0.2 mg/m^3)
Uses - Precursor in the production of polyurethane plastics, production of foams, surface coatings, adhesives, rubbers, and fibers. Since MDI is considerably less volatile than toluene diisocyanate (TDI), it is generally safer to use even though it has approximately the same toxicity. Partially prepolymerized MDI is even safer and wherever possible MDI or partially prepolymerized MDI should be substituted for TDI.
Occupations with potential exposure -

Abrasion resistant rubber makers	Plasticizer workers
Adhesive workers	Polyurethane foam makers
Aircraft builders	Polyurethane sprayers
Insulation workers	Ship burners
Isocyanate resin workers	Ship welders
Lacquer workers	Spray painters
Mine tunnel coaters	Textile processors
Organic chemical synthesizers	Upholstery makers
Plastic foam makers	Wire coating workers

Toxicology -

Local effects - MDI vapor is highly irritating to eyes, nose and throat, and produces conjunctivitis and coryza-like symptoms. Although MDI liquid is mildly irritating to skin, dermatitis is rare. Continued contact may darken and harden skin.

Systemic effects - Pulmonary irritation, and in some cases pulmonary sensitization, may cause nonproductive cough, wheezing, shortness of breath, and tightness of chest. Diagnoses of bronchitis and bronchial asthma are frequently made.

Medical Surveillance - Preplacement: Medical history; 14" x 17" posterior-anterior chest x-ray; total white blood cell count with differential; pulmonary functions (FVC, FEV_1); and absolute eosinophil count. History should focus on the presence and degree of respiratory symptomatology.
Periodic: Annually as above with the exception of the chest x-ray. Diagnosis of sensitization to isocyanates should exclude the worker from further exposure.

References - Woolrich, M.D.; and Rye, W.A.: Urethanes, J. Occup. Med. 11:184-190, April 1969.

Also see references under Toluene Diisocyanate.

Methyl n-Butyl Ketone (2-Hexanone)

TWA - 100 ppm (410 mg/m^3)
TLV® - 100 ppm (410 mg/m^3)
Uses - Solvent for nitrocellulose, resins, oils, fats, waxes, lacquers, and paints. Solvent in lacquer and varnish removers.
Occupations with potential exposure -

Cleaning compound workers	Painters
Dewaxers	Paint removers
Dope processors	Printers
Drug makers	Printing ink makers
Dye makers	Shoemakers
Explosive makers	Smokeless powder makers
Lacquerers	Solvent workers
Lacquer makers	Stainers
Lacquer removers	Stain makers
Oil processors	Varnish makers
Organic chemical synthesizers	Varnish removers

Toxicology -

Local effects - Because of its fat solvent action, this ketone may be expected to defat the skin with resultant dermatitis if repeated prolonged skin contact should occur. Also capable of causing mild eye irritation with transient corneal injury. The inhalation of the vapors of this material may result in upper respiratory tract irritation.

Systemic effects - Primary effects occur in the central nervous system. Large, acute exposures cause narcosis and death. Long-term, lower level exposures cause a significant peripheral neuropathy with a glove-stocking distribution and eventual flacid paralysis. The situation clinically simulates spinal polio. Other effects occur in the lungs, liver, and kidney.

Medical Surveillance - Workers exposed to levels above 25 ppm must have a complete neurological examination, including electromyography and nerve conduction studies, prior to employment and monthly thereafter. Semiannual exams are required for workers whose exposures do not exceed 25 ppm.

Remarks - TLV is not protective against the neurological effects. At no time should exposure exceed 100 ppm. This substance is far more dangerous than previously thought and every attempt should be made to find a suitable substitute.

References - American Conference of Governmental Industrial Hygienists, Am. Ind. Hyg. Assoc. J. 22:325, 1961.
Occupational Health and Safety Reporter, Vol. 3, 41:1294-95, 14 March 1974.
Schrenk, H.H.; Yant, W.P. and Patty, F.A.: US Public Health Repts. 51:624, 1936.
Smyth, Jr., H.F.; Carpenter, C.P.; Weil, C.S. and Pozzani, U.C.: Arch. Ind. Hyg. Occup. Med. 10:61, 1954.
Smyth, Jr., H.F.: Am. Ind. Hyg. Assoc. Quart. 14:129, 1956.

Methyl Chloroform (1,1,1-trichloroethane)

TWA - 350 ppm (1,900 mg/m^3)
TLV® - 350 ppm (1,900 mg/m^3)
Uses - Solvent.
Occupations with potential exposure -

Dry cleaners	Metal degreasers
Machinery cleaners	Stain removers

Toxicology -

Local effects - Liquid and high vapor concentrations will irritate eyes on contact. Repeated skin contact will produce a dry, scaly, fissured dermatitis.

Systemic effects - Narcotic effects of dizziness, incoordination, drowsiness, and unconsciousness have been produced by acute exposure to vapor concentrations approaching 1,000 ppm. If the worker is not removed after he has been overcome, death can result from respiratory failure or possible ventricular arrhythmia. Fatty degeneration of liver occurred in laboratory animals undergoing chronic exposure to high concentrations. In human subjects, transient elevation of urinary urobilinogen has been noted following exposure to anesthetic concentrations.

Medical Surveillance - Alk Phosph and SGOT annually.

References - Stewart, R. D.; Gay, H. H.; Erley, D. S.; Hake, C. L., and Schaffer, A. W.: Human exposure to 1,1,1-trichloroethane vapor; relationship of expired air and blood concentrations to exposure and toxicity. Am. Indust. Hyg. Assoc. J. 22:252, 1961.
Torkelson, T. R.; Oyen, F.; McCollister, D. D., and Rowe, V. K.: Toxicity of 1,1,1-trichloroethane as determined on laboratory animals and human subjects. Am. Indust. Hyg. Assoc. J. 19:353, 1958.

Methylene Chloride (dichloromethane, methylene dichloride, methylene bichloride)

TWA - 500 ppm (1,750 mg/m^3), 1,000 ppm C
* - 100 ppm (proposed), 300 ppm C (proposed) (see Remarks)
TLV® - 500 ppm (1,750 mg/m^3)
Uses - Aerosols, degreasing, fumigants, lacquers, paint removers, waxes.
Occupations with potential exposure -

Degreasers	Lacquerers
Dentists	Leather workers
Dewaxers	Paint removers
Dyers	Stain removers
Fumigators	Varnish removers

Toxicology -

Local effects - Repeated contact with this solvent will cause a dry, scaly, fissured dermatitis. Liquid and vapor are irritating to eyes and upper respiratory tract.

Systemic effects - Methylene chloride acts as narcotic in high concentrations causing headache, nausea, vomiting, drowsiness, incoordination, paresthesias, and coma. High concentrations may also produce bronchitis, pulmonary edema and liver injury. Recent studies have demonstrated that exposure to levels of methylene chloride near the TWA promptly (1 to 2 hours) initiates the formation of significant quantities of carbon monoxide in human subjects. Evidence suggests that carbon monoxide may be a metabolite of methylene chloride and that exposure to concentrations of methylene chloride below allowable limits may result in the formation of carbon monoxide in amounts that exceed the allowable limit for carbon monoxide.

Medical Surveillance - Exclude asthmatics and those with chronic cardiopulmonary disease. At exposure levels greater than one-half of allowable limits, consideration should be given to obtaining carboxyhemaglobin levels on exposed personnel at regular intervals. Exposures should be controlled to protect against levels of carboxyhemoglobin in excess of 5 percent.

Remarks - Routes of Entry: Inhalation of vapor; percutaneous absorption of liquid.
*See NIOSH Criteria Document (Appendix D).

Reference - Stewart, R.D., et. al.: Carboxyhemoglobin Elevation after Exposure to Dichloromethane, Science. 176:295, 1972.

Methyl Isobutyl Carbinol (methylamyl alcohol)

TWA - 25 ppm (100 mg/m^3), Skin
TLV® - 25 ppm (100 mg/m^3)
Uses - Hydraulic fluids, lubricant additives, plasticizers, lacquers.
Occupations with potential exposure -

- Lacquerers
- Mechanics
- Plastic workers

Toxicology -

Local effects - Slightly irritating to eyes, nose, throat, and skin.

Systemic effects - At high concentrations, narcotic.

Medical Surveillance - None required.

References - See General References (Appendix A).

Naphtha, Petroleum naphtha (ligroin, benzine, petroleum ether, petroleum benzine); Coal tar naphtha (hi-flash naphtha)

TWA - 100 ppm (400 mg/m^3)
TLV® - 100 ppm (400 mg/m^3) .
Uses - Lighter fluid, insecticides, degreasing, paint, varnish, stains, waxes.
Occupations with potential exposure -

Degreasers	Stainers
Dry cleaners	Varnishers
Laboratory workers	Waxers
Painters	Wool processors

Toxicology -

Local effects - Primary skin irritant.

Systemic effects - The naphthas may produce symptoms and signs of central nervous system depression similar to those resulting from gasoline intoxication. Coal tar naphtha, a mixture of aromatic hydrocarbons, including toluene, xylene, and pseudocumene has a greater propensity to produce toxicity than petroleum naphtha, consisting principally of a mixture of paraffin hydrocarbons.

Medical Surveillance - SGOT, UA and hematocrit annually.

Remarks - TLV for Petroleum Ether is 500 ppm (2,000 mg/m^3). Impure coal tar naphtha may be more toxic than pure product. Consideration should be given to the benzene exposure possibly resulting from the use of petroleum naphtha containing as little as 2 percent benzene by weight.

References - Elkins, H.B.; Comproni, E.M., and Pagnotto, L.D.: Industrial benzene exposure from petroleum naphtha. 2, Pertinent physical properties of hydrocarbon mixtures. Am. Indust. Hyg. Assoc. J. 24:99, 1963.
Gerarde, H.W.: Toxicology and Biochemistry of Aromatic Hydrocarbons. Elsevier Publishing Co. Amsterdam, and Princeton, NJ. 1960.
Pagnotto, L.D.; Elkins, H.B.; Brugsch, H.G., and Walkley, J.E.: Industrial benzene exposure from petroleum naphtha. 1, Rubber coating industry. Am. Indust. Hyg. Assoc. J. 22:417, 1961.

Naphthylamine (Beta)

TWA - See Carcinogens (Appendix F)
TLV® - 0 ppm (0.0 mg/m^3)
Uses - Dyes, contaminant in alpha-naphthylamine research (cancer), analytical standard.
Occupations with potential exposure -

Beta-naphthylamine workers	Dye makers
Cancer researchers	Laboratory workers

Toxicology -

Local effects - Beta-naphthylamine is mildly irritating to skin and has produced contact dermatitis.

Systemic effects - A metabolite, the 1-hydroxy derivative of beta-naphthylamine, is a potent carcinogen. The metabolite acts on urinary bladder mucosa causing cystitis and papillomata which may become malignant. Symptoms are frequent urination, dysuria, and hematuria, which appear after several years of exposure or several years after last exposure. Alpha-naphthylamine is unimportant toxicologically except for its frequent contamination by beta-naphthylamine.

Medical Surveillance - Urinary cytology and UA quarterly; cystoscopy annually. See remarks.

Remarks - Known potent human carcinogen. Make every effort to use a substitute. No exposure or contact by any route, as detected by most sensitive methods, shall be permitted.

References - Case, R.A.M.; Hosker, M.E.; McDonald, D.B., and Pearson, J.T.: Tumors of the urinary bladder in workmen engaged in the manufacture and use of certain dyestuff intermediates in the British chemical industry. 1, The role of aniline, benzidine, alpha-naphthylamine, and beta-naphthylamine. Brit. J. Indust. Med. 11:75, 1954.
von Oettingen, W.F.: Poisoning, a Guide to Clinical Diagnosis and Treatment. 2nd ed. W.B. Saunders Co., Philadelphia, 1958.

Nickel and Compounds

TWA - 1 mg/m^3
TLV® - 1 mg/m^3
Uses - Plating anodes, alloys, catalyst.
Occupations with potential exposure -

Battery, storage and recharging	Nickel alloy makers
Ceramic makers	Nickel refiners
Dyers	Nickel smelters
Electroplaters	Nickel workers
Enamelers	Organic chemical synthesizers
Gas mask makers	Petroleum refinery workers
Jewelers	Steel makers, stainless
Magnet makers	Textile dyers

Toxicology -

Local effects - Nickel salts produce allergic contact dermatitis. A type of dermatitis referred to as nickel itch may be seen in nickel miners, smelters, and refiners. This condition is characterized by an erythematous, papular, pruritic rash, often beginning in web of fingers and spreading to fingers, wrists, and forearms.

Systemic effects - Nickel carbonyl is thought to be the most toxic of nickel compounds. Metallic nickel and its salts are considered to be of very low level of toxicity when taken into the body. There has been reported an increase in incidence of cancer of lung and ethmoid sinuses in men exposed to dust in nickel refining.

Medical Surveillance - Annual sputum cytology.

References - Doll, R.: Cancer of the lung and nose in nickel workers. Brit. J. Indust. Med. 15:217, 1958.
Morgan, J.G.: Some observations on the incidence of respiratory cancer in nickel workers. Brit. J. Indust. Med. 15:224, 1958.
Sunderman, F.W. and Kincaid, J.F.: Nickel poisoning. 2, Studies on patients suffering from acute exposure to vapors of nickel carbonyl. J. Am. Med. Assoc. 155:889, 1954.

Octane

TWA - 500 ppm (2,350 mg/m^3)
TLV® - 400 ppm (1,900 mg/m^3)
Uses - Degreasing, fuel.
Occupations with potential exposure -

Garage workers
Mechanics

Toxicology -

Local effects - Repeated or prolonged exposure, due to defatting of skin can lead to scaly, fissured dermatitis.

Systemic effects - Octane in concentrations of 6,600 to 13,700 ppm (0.66 to 1.37 percent) caused narcosis in mice within 30 to 90 minutes. No deaths or convulsions resulted from these exposures to concentrations below 13,700 ppm (1.37 percent).

Medical Surveillance - None required.

References - See General References (Appendix A).

Ozone

TWA - 0.1 ppm (0.2 mg/m^3)
TLV® - 0.1 ppm (0.2 mg/m^3)
Uses - Disinfectant, bleaches.
Occupations with potential exposure -

Air treaters	Industrial waste treaters
Arc cutters	Photoengravers
Arc welders	Textile bleachers
Electroplaters	UV lamp workers

Toxicology -

Local effects - Irritant to eyes and mucous membranes.

Systemic effects - Pulmonary edema and hemorrhage may result from severe exposure. Less severe exposure may produce headache, malaise, shortness of breath and drowsiness.

Medical Surveillance - None.

Reference - Stokinger, H.E.: Ozone toxicity. A review of the literature through 1953. A.M.A. Arch. Indust. Hyg. & Occup. Med. 9:367, 1954.

Pentachlorophenol

TWA - 0.5 mg/m^3, Skin
TLV® - 0.5 mg/m^3
Uses - Applied to wood, starches, adhesives, proteins, leather, oils, paint, latex and rubber to control fungi, insects, slime and algae.
Occupations with potential exposure -

Box makers
Pest control workers

Toxicology -

Local effects - Intense irritation to the eyes, mucous membranes and upper respiratory tract from solutions, dusts or sprays containing pentachlorophenol.

Systemic effects - Pentachlorophenol causes a radical uncoupling of oxidation and phosphorylation cycles in tissues. This produces a markedly increased basal metabolic rate and a marked temperature increase. Observed symptoms of intoxication resulting from careless use includes: anotexia, anesthesia, hyperpyrexia, sweating, dyspnea, and in severe cases a rapidly progressive coma and death.

Medical Surveillance - None recommended.

References - Deichmann, W.B., and Schaefer, L.J.: Ind. Eng. Chem. 14:310, 1942.
Menor, J.A.: Brit. J. Med. 1:1156, 1958.

Perchloroethylene (tetrachloroethylene, carbon dichloride, ethylene tetrachloride)

TWA - 100 ppm (670 mg/m^3), 200 ppm C
TLV® - 100 ppm (670 mg/m^3)
Uses - Degreaser, dry cleaning, antihelmintic, dope, inks, waxes.
Occupations with potential exposure -

Cellulose ester processors	Paraffin processors
Cellulose ether processors	Perchloroethylene workers
Degreasers	Printers
Dope processors	Rubber workers
Dry cleaners	Soap workers
Electroplaters	Solvent workers
Fumigant workers	Tar processors
Heat transfer workers	Vacuum tube makers
Metal degreasers	Wax makers
Organic chemical synthesizers	Wool scourers

Toxicology -

Local effects - Repeated contact with liquid causes a dry, scaly, fissured dermatitis. High concentrations produce eye and nose irritation.

Systemic effects - Primary systemic effect is narcosis, with symptoms of headache, dizziness, nausea, incoordination, and somnolence. Repeated exposures to high concentrations can produce a mild hepatitis.

Medical Surveillance - Alk Phosph and SGOT annually.

Remarks - Special Diagnostic Test: Analysis of blood for perchloroethylene. Symptoms may occur below TLV.

References - Stewart, R. D.; Erley, D. S.; Schaffer, A. W., and Gay, H. H.: Accidental vapor exposure to anesthetic concentrations of a solvent containing tetrachloroethylene. Indust. Med. & Surg. 30:327, 1961.
Stewart, R. D.; Gay, H. H.; Erley, D. S.; Hake, C. L., and Schaffer, A. W.: Human exposure to tetrachloroethylene vapor. Relationship of expired air and blood concentrations to exposure and toxicity. Arch. Environ. Health. 2:516, 1961.

Phenol

TWA - 5 ppm (19 mg/m^3), Skin
TLV® - 5 ppm (19 mg/m^3)
Uses - Explosive, paint remover, wood preservative, and plastic production.
Occupations with potential exposure -

- Coal tar workers
- Dye makers
- Dyers
- Etchers
- Explosive workers
- Gas workers, illuminating
- Herbicide makers
- Lampblack makers
- Lubricating oil processors
- Paint removers
- Pentachlorophenol makers
- Phenol workers
- Photographic material workers
- Picric acid makers
- Resin makers
- Rubber reclaimers
- Rubber workers
- Textile printers
- Weed killers
- Wood preservers

Toxicology -

Local effects - A primary irritant possessing strong corrosive properties for all tissues of the body.

Systemic effects - Acute poisoning is mainly characterized by central nervous system manifestations including tinnitus, vertigo, tremor, excitement, and convulsions. Pneumonia often follows. Chronic phenol poisoning is characterized by headache, fatigue, cough, anorexia, insomnia, nervousness, paresthesias, weight loss, and cachexia. Renal and hepatic damage frequently follow phenol intoxication.

Medical Surveillance - SGOT and urinalysis annually.

Remarks - Urinary phenol determination can also be performed to evaluate acute exposure.

References - Evans, S.J.: Acute phenol poisoning. Brit. J. Indust. Med. 9:227, 1952.
von Oettingen, W.F.: Poisoning, a Guide to Clinical Diagnosis and Treatment. 2nd ed. W.B. Saunders Co., Philadelphia, 1958.

Phosphorus and Compounds

TWA - 0.1 mg/m^3
TLV® - 0.1 mg/m^3
Uses - Phosphors, pyrotechnics, rodenticides.
Occupations with potential exposure -

- Bronze alloy makers
- Electroluminescent coating makers
- Incendiary makers
- Metallic phosphide makers
- Metal refiners
- Munitions workers
- Pesticide workers
- Phosphoric acid makers
- Phosphoric anhydride makers
- Phosphorus workers
- Pyrotechnic makers
- Rat poison workers
- Red phosphorus makers
- Semiconductor makers
- Smoke bomb workers

Toxicology -

Local effects - Skin contact with yellow phosphorus results in production of severe burns. In addition, the following phosphorus compounds are reported to be potent irritants of skin, eyes, and mucous membranes of nose, throat, and respiratory tract:

- Phosphorus trichloride
- Phosphorus pentachloride
- Phosphorus oxychloride
- Phosphorus tribromide
- Phosphorus pentabromide
- Phosphorus trisulfide
- Phosphorus pentasulfide
- Phosphorus sesquisulfide
- Phosphoric acid

Systemic effects - Ingestion of yellow phosphorus produces severe poisoning, beginning with local gastrointestinal irritation, progressing to systemic poisoning. Shock may ensue rapidly. If death is not immediate, patient may succumb later to liver, kidney, or heart failure brought about by direct action of phosphorus on these organs. Inhalation of fumes produced by the phosphorus compounds listed above may cause irritation of pulmonary tissues with resultant acute pulmonary edema. Chronic phosphorus poisoning is result of continued absorption of small amounts of yellow phosphorus. This form of intoxication is characterized by periostitis with suppuration, ulceration, necrosis, and severe deformity of the lower jaw.

Medical Surveillance - Roentgenographic examination of lower jaw to detect possible necrosis of mandible and dental examination yearly.

References - Caley, J.P. and Kellock, I.A.: Acute yellow phosphorus poisoning with recovery. Lancet. 1:539, 1955.
Heimann, H.: Chronic phosphorus poisoning. J. Indust. Hyg. and Toxicol. 28:142, 1946.
Rubitsky, H.J. and Myerson, R.M.: Acute phosphorus poisoning. Arch. Int. Med. 83:164, 1949.

n-Propyl Alcohol

TWA - 200 ppm (500 mg/m^3)
TLV® - 200 ppm (500 mg/m^3)
Uses - Antifreeze, deicers, inks, lacquers, varnishes, stains, rocket fuels.
Occupations with potential exposure -

Garage workers	Printers
Lacquerers	Rocket fuel handlers
Nurses	Stainers
Physicians	Varnishers

Toxicology -

Local effects - Inhalation of vapor can produce mild irritation of conjunctiva and mucous membranes of upper respiratory tract. Liquid very irritating to eyes and mucosa.

Systemic effects - No industrial poisoning has been recorded. n-Propyl alcohol is potentially narcotic.

Medical Surveillance - None required.

Reference - Henson, E.V.: The toxicology of some aliphatic alcohols; part 1. J. Occup. Med. 2:442, 1960.

Propylene Dichloride (1,2-dichloropropane, propylene chloride)

TWA - 75 ppm (350 mg/m^3)
TLV® - 75 ppm (350 mg/m^3)
Uses - Stains, waxes, dry cleaning, fumigants, degreasers.
Occupations with potential exposure -

Cellulose plastic makers	Organic chemical synthesizers
Dry cleaners	Propylene dichloride workers
Dry cleaning fluid makers	Rubber makers
Fumigant workers	Scouring compound makers
Metal degreasers	Stain removers
Oil processors	Wax makers

Toxicology -

Local effects - Repeated or prolonged contact with liquid can produce a dry, scaly, fissured dermatitis. May be irritating to eyes and other mucous membranes.

Systemic effects - Produces marked narcosis. May cause fatty degeneration of liver, kidneys and heart.

Medical Surveillance - LDH, SGOT, UA annually.

Remarks - Carcinogenic (hepatomas) in mice.

Reference - Heppel, L.A.; Neal, P.A.; Highman, B., and Porterfield, V.T.: Toxicology of 1,2-dichloropropane (propylene dichloride). 1, Studies on effects of daily inhalations. J. Indust. Hyg. & Toxicol. 28:1, 1946.

Silica

TWA - Quartz (respirable) = $\frac{250}{\% SiO_2 + 5}$ mppcf

Quartz (respirable) = $\frac{10\ mg/m^3}{\% SiO_2 + 2}$

Quartz (total dust) = $\frac{30\ mg/m^3}{\% SiO_2 + 2}$

TLV® - Quartz (respirable) = $\frac{300}{\%\ quartz + 10}$ mppcf

Quartz (respirable) = $\frac{10\ mg/m^3}{\%\ quartz + 2}$

Quartz (total dust) = $\frac{30\ mg/m^3}{\%\ quartz + 3}$

Uses - Sand or abrasive blasting, casting, pottery and glass manufacture.
Occupations with potential exposure -

Abrasive blasters	Rock drillers
Coal miners	Sand blasters
Grinders	Sand casters
Hardrock blasters	Sand loaders
Miners	Simulated terrain makers
Pottery makers	Stone workers
Quarry workers	Test drivers

Toxicology -

Local effects - Local effects either to mucous membranes, eyes, or skin are negligible.

Systemic effects - The primary long-term danger is the development of silicosis, which is a fibrotic lung disease eventually resulting in severe respiratory impairment and predisposing to pulmonary tuberculosis. Dusts containing free silica with dangerous size particles (below 5 microns in diameter) are capable of producing silicosis if inhaled in high enough concentrations over a sufficient period of time.

Medical Surveillance - Chest x-ray, pulmonary function tests including FVC and $FEV_{1.0}$, and tuberculosis skin testing every 2 years for workers with less than 10 years work with silica and annually for those with over 10 years of work exposure.

Remarks - Most grinding operations no longer use silica as the abrasive.

Reference - Hunter, D.: The Diseases of Occupations, Little, Brown, and Company, Boston, 1962.

Silver and Compounds

TWA - 0.01 mg/m^3
TLV® - 0.01 mg/m^3
Uses - Silvering of mirrors, electrical equipment, photographic chemicals, solder.
Occupations with potential exposure -

Algicide makers	Jewelry makers
Alloy makers	Lead refiners
Artificial rain makers	Metal inlayers
Bactericide makers	Mirror makers
Battery rechargers	Optical workers
Bearing metal makers	Organic chemical synthesizers
Ceramic makers	Silver bromide makers
Chemical equipment makers	Silver engravers
Copper refiners	Silver finishers
Cutlery makers	Silver platers
Dental alloy makers	Silver polishers
Electric conductor makers	Silver reclaimers
Electric equipment makers	Silversmiths
Gas mask makers	Silver workers
Glass makers	Solder workers, hard
Electronic workers	Water treaters
Gold refiners	

Toxicology -

Local effects - Localized industrial argyria (argyrism) is caused by implantation of silver particles in skin and is manifested as small bluish-black spots, usually on hands and forearms. Silver nitrate is irritating to skin and mucous membranes and can temporarily discolor skin.

Systemic effects - Industrial argyria from ingestion of silver compounds has been reported, but is no longer seen. It resembled the bluish-gray discoloration of eyes and skin seen in generalized argyria from therapeutic ingestion or injection of silver salts. Depth of color in argyria is greater in those areas exposed to light. When silver or its salts are inhaled in industrial exposures, much of the silver is deposited in elastic tissue of lungs (pulmonary argyria), but eventually the bluish-gray discoloration appears in eyes and skin. Bronchitis and emphysema have been described in workers with pulmonary argyria, but a cause and effect relationship has not

been demonstrated. Except for its cosmetic disfigurement, argyria is generally considered to be benign.

Medical Surveillance - Annual chest x-ray (14" x 17"). Annual FEV_1, FEV and VC for employees with radiological evidence of pulmonary argyria.

References - Browning, E.: Toxicity of Industrial Metals. Butterworths, London, 1961.
Harker, J.M. and Hunter, D.: Occupational argyria. Brit. J. Dermat. 47:441, 1935.
Heimann, H.: Toxicity of metallic silver. Indust. Bull. (N.Y. State Dept. Labor). 22:81, 1943.
Holden, R.F.,Jr.: Observations in argyria. J. Lab. & Clin. Med. 36:837, 1950.

Sodium and Potassium Hydroxides

TWA - sodium hydroxide, 2 mg/m^3
TLV® - 2 mg/m^3
Uses - Bleach, electroplating, laboratory reagent.
Occupations with potential exposure -

- Bleachers
- Bleach makers
- Bronzers
- Degreasers
- Electroplaters
- Enamelers
- Engravers
- Etchers
- Furniture polishers
- Housekeepers
- Laboratory workers, chemical
- Laundry workers
- Lithographers
- Paint removers
- Petroleum refinery workers
- Photoengravers
- Potassium hydroxide workers
- Printers
- Rubber reclaimers
- Soap makers
- Sodium hydroxide workers
- Textile bleachers
- Varnish removers

Toxicology -

Local effects - Both compounds exert an extremely corrosive action on skin, eyes and mucous membranes.

Systemic effects - Systemic effects are due entirely to local tissue injury. Extreme pulmonary irritation may result from inhalation of dust or mist.

Medical Surveillance - None recommended.

Remarks - Aqueous solution of sodium hydroxide (caustic soda or caustic alkali) or potassium hydroxide (caustic potash or caustic alkali) is known as lye; the sodium hydroxide solution is also referred to as soda lye. Sodium hydroxide added to calcium oxide produces soda lime. Water added to calcium oxide (lime or quicklime) produces calcium hydroxide or slaked lime. Washing soda (soda ash or sal soda) is sodium carbonate combined with 10 molecules of water. Baking soda is sodium bicarbonate. Chloride of lime is a mixture of calcium chloride, calcium hypochlorite and calcium hydroxide.

References - See General References (Appendix A).

Stoddard Solvent (Varsol)

TWA - 500 ppm (2,950 mg/m^3)
TLV® - 200 ppm (1,150 mg/m^3)
Uses - Degreasers, metal cleaner, dry cleaning, paint thinners.
Occupations with potential exposure -

Dry cleaners	Painters
Lacquerers	Stainers
Mechanics	Varnishers
Metal cleaners	

Toxicology -

Local effects - Repeated or prolonged exposure, due to defating of skin, can lead to scaly, fissured dermatitis.

Systemic effects - Pharmacologically and toxicologically comparable to octane.

Medical Surveillance - None required.

References - See General References (Appendix A).

Sulfur Dioxide

TWA - 5 ppm (13 mg/m^3)
TLV® - 5 ppm (13 mg/m^3)
Uses - Intermediate in chemical manufacture, refrigeration, bleaching, fumigating and preserving.
Occupations with potential exposure -

- Boiler water treaters
- Diesel engine operators
- Diesel engine repairmen
- Disinfectors
- Firemen
- Foundry workers
- Fumigators
- Furnace operators
- Glass makers
- Ice makers
- Meat preservers
- Oil processors
- Ore smelter workers
- Organic sulfonate makers
- Petroleum refinery workers
- Preservative makers
- Refrigeration workers
- Sulfite makers
- Sulfur dioxide workers
- Sulfuric acid makers
- Tannery workers
- Textile bleachers
- Thermometer makers
- Thionyl chloride makers
- Wool bleachers

Toxicology -

Local effects - Gaseous sulfur dioxide is an irritant to conjunctiva and mucous membranes of the upper respiratory tract. High exposure may produce laryngeal edema and death from asphyxiation. Liquid sulfur dioxide is a skin irritant. Corneal injury with blindness has resulted from liquid splashes into eyes.

Systemic effects - Severe acute symptoms are unusual since gas is sufficiently irritant to compel the workers to flee. Inhalation of high concentrations may produce bronchitis, pneumonitis, pulmonary edema, and death. Studies of chronic sulfur dioxide exposure in humans have indicated no appreciable danger to health. Nasopharyngitis, fatigue, altered sense of taste and smell, and dyspnea on exertion have been said to result from long continued low exposures.

Medical Surveillance - Annual history and physical examination with the history to focus on complaints of mucous membrane irritation and the physical to emphasize the eyes and the cardiopulmonary system. Annual pulmonary function testing to include FEV_1, FEV, and VC.

Remarks - Persons with lung disease should be excluded from employment in a sulfur dioxide environment.

References - Anderson, A.: Possible long-term effects of exposure to sulfur dioxide. Brit. J. Indust. Med. 7:82, 1950.
Kehoe, R.A.; Machle, W.F.; Kitzmiller, K., and Leblanc, T.J.: On the effects of prolonged exposure to sulfur dioxide. J. Indust. Hyg. 14:159, 1932.

Sulfuric Acid (oil of vitriol, spirit of vitriol, hydrogen sulfate)

TWA - 1 mg/m^3
TLV® - 1 mg/m^3
Uses - Chemical manufacture, metal production, manufacture of explosives.
Occupations with potential exposure -

Aluminum sulfate makers	Food processors
Ammonium sulfate makers	Fur processors
Battery storage workers	Galvanizers
Cellulose workers	Jewelers
Dye makers	Laboratory workers, chemical
Electroplaters	Metal cleaners
Explosive makers	

Toxicology -

Local effects - Sulfuric acid is an irritant to the conjunctiva and mucous membranes of the upper respiratory tract. The acid may also produce erosion of teeth, usually the incisors. Liquid may produce severe burns and ulceration of skin.

Systemic effects - Systemic effects are not well recognized. Human experimental studies have revealed that rapid shallow respiration may occur following exposure to low concentrations of sulfuric acid mist below the taste-odor-irritation threshold. Pulmonary fibrosis, bronchiectasis, and emphysema have been reported from acute exposure to fuming sulfuric acid and sulfuric acid mist.

Medical Surveillance - Dental examination for tooth erosion every 3 years.

References - Amdur, M.O.; Silverman L. and Drinker, P.: Inhalation of sulfuric acid mist by human subjects. A.M.A. Arch. Indust. Hyg. & Occup. Med. 6:305, 1952.
Goldman, A. and Hill, W.T.: Chronic bronchopulmonary disease due to inhalation of sulfuric acid fumes. A.M.A. Arch. Indust. Hyg. & Occup. Med. 8:205, 1953.
Malcolm, D. and Paul, E.: Erosion of teeth due to sulfuric acid in the battery industry. Brit. J. Indust. Med. 18:63, 1961.

Tetrachloroethane (acetylene tetrachloride)

TWA - 5 ppm (35 mg/m^3), Skin
TLV® - 5 ppm (35 mg/m^3)
Uses - Solvent.
Occupations with potential exposure -

Storage tank cleaners	Tetramethyl lead mixers
Tetramethyl lead blenders	Tetramethyl lead workers
Tetramethyl lead makers	

Toxicology -

Local effects - Repeated or prolonged contact with this low grade primary irritant can produce a scaly and fissured dermatitis.

Systemic effects - Most toxic of the chlorinated hydrocarbons. Narcosis is the early effect. Later, liver damage resulting in acute yellow atrophy occurs. Fatty degeneration of the kidneys and the myocardium may also be produced.

Medical Surveillance - Semiannual SGOT and Alk Phosph.

Reference - von Oettingen, W.F.: The halogenated aliphatic, olefinic, cyclic, aromatic, and aliphatic-aromatic hydrocarbons including the halogenated insecticides; their toxicity and potential dangers. Pub. Health Service Pub. No. 414. U.S. Government Printing Office, Washington, D.C., 1955.

Tetryl (trinitrophenylmethylnitramine, nitramine, tetranitromethylaniline, pyrenite, picrylmethylnitramine, picrylnitromethylamine)

TWA - 1.5 mg/m^3
TLV® - 1.5 mg/m^3
Uses - Explosive.
Occupations with potential exposure -

Ammunition makers	Indicator makers, chemical
Detonator makers	Tetryl workers
Explosive workers	

Toxicology -

Local effects - Tetryl is a potent sensitizer, and allergic contact dermatitis is common. Contact may stain skin and hair yellow or orange; workers with such stains have been referred to as canaries. Tetryl dust is sometimes irritating to eyes and nose, causing conjunctivitis, sneezing, and epistaxis.

Systemic effects - Cough is a common symptom among workers initially exposed to large amounts of dust, but chest roentgenograms reveal no pulmonary disease. Systemic intoxication is practically never encountered. In the few cases of liver damage that have been reported, exposure was massive. Tetryl workers are frequently exposed to trinitrotoluene and other explosives, making it difficult to establish the specific agent producing the systemic symptoms.

Medical Surveillance - Annual physical examination with emphasis on the skin and including an evaluation of pulmonary function. Semiannual SGOT and hematocrit.

Remarks - Special Diagnostic Test: Webster's reagent, a dilute solution of sodium hydroxide in ethyl alcohol, is discolored dark brown by tetryl on skin.

References - Bergman, B.B.: Tetryl toxicity; a summary of ten years' experience. A.M.A. Arch. Indust. Hyg. & Occup. Med. 5:10, 1952.
Hardy, H.L. and Maloof, C.C.: Evidence of systemic effect of tetryl; with summary of available literature. Arch. Indust. Hyg. & Occup. Med. 1:454, 1950.

Thallium and Compounds

TWA - 0.1 mg/m^3
TLV® - 0.1 mg/m^3
Uses - Rodenticide, optical systems, gasoline additive, photoelectric cells.
Occupations with potential exposure -

Alloy makers	Insecticide workers
Dye makers	Photoelectric cell makers
Glass makers	Rodenticide workers
Infrared instrument makers	Textile workers

Toxicology -

Local effects - Some thallium salts may produce skin irritation.

Systemic effects - Thallium may act as a cumulative poison; that is, repeated small doses which would individually produce little or no effect may be stored in the body until a harmful or even lethal dose accumulates. Acute effects include severe gastroenteritis, abdominal pain, and collapse. Subacute or chronic effects include nausea, vomiting, leg and abdominal cramping, paresthesia of lower limbs, irritability, anorexia, stomatitis, dry scaly skin, metallic taste, garlic-like foul breath, visual disturbances, convulsions, delayed loss of hair, and kidney damage.

Medical Surveillance - Analyze urine for thallium annually. Urinalysis annually.

Remarks - Inhalation of dust and fume. Ingestion and percutaneous absorption of dust are routes of entry.

References - Jacobs, M.B.: The determination of thallium in urine. Am. Indust. Hyg. Assoc. J. 23:411, 1962.
Richeson, E.M.: Industrial thallium intoxication. Indust. Med. & Surg. 27:607, 1958.
Truhaut, R.: The toxicology of thallium. J. Occup. Med. 2:334, 1960.

Toluene (toluol, methylbenzene, phenylmethane, methylbenzol)

TWA - 200 ppm (750 mg/m^3), 300 ppm C
TLV® - 100 ppm (375 mg/m^3)
Uses - Solvent.
Occupations with potential exposure -

Dye makers	Pesticide workers
Enamel makers	Printers
Explosive makers	Solvent workers
Histology technicians	Stainers
Laboratory workers	TNT makers
Lacquerers	Textile workers
Painters	Toluidine makers
Paint thinner makers	Wax makers

Toxicology -

Local effects - Liquid or vapor is primary irritant of skin, eyes, and mucous membranes of upper respiratory tract. Small corneal vacuoles have been produced by mixtures of substances containing toluene.

Systemic effects - Primary effect of both acute and chronic exposures is central nervous system depression. Symptoms and signs include headache, dizziness, weakness, fatigue, paresthesia, disturbance of coordination and equilibrium, insomnia, and loss of consciousness. Onset and severity of symptoms will depend upon degree and type of exposure. Hematologic effects are not prominent; however, temporary and slight lymphocytosis has occasionally been observed.

Medical Surveillance - CBC and UA annually. (See Remarks.)

Remarks - Analysis of urine for hippuric acid, and of blood for toluene are possible. Toluene may be contaminated with benzene. See NIOSH Criteria Document (Appendix D).

References - Gerarde, H.W.: Toxicology and Biochemistry of Aromatic Hydrocarbons. Elsevier Publishing Co., Amsterdam, and Princeton, N.J., 1960.
von Oettingen, W.F.: Poisoning, a Guide to Clinical Diagnosis and Treatment. 2nd ed. W.B. Saunders Co., Philadelphia, 1958.

Toluene Diisocyanate (tolylene diisocyanate, TDI)

TWA - 0.02 ppm (0.14 mg/m^3), C
TLV® - 0.02 ppm (0.14 mg/m^3)
* - 0.005 ppm (0.036 mg/m^3) (proposed) (See Remarks)
Uses - Precursor in the production of polyurethane plastics, production of foams, surface coatings, adhesives, rubbers, and fibers.
Occupations with potential exposure -

Abrasion resistant rubber makers	Polyurethane foam makers
Adhesive workers	Polyurethane sprayers
Aircraft builders	Ship burners
Insulation workers	Ship welders
Isocyanate resin workers	Spray painters
Lacquer workers	Textile processors
Mine tunnel coaters	Tolylene diisocyanate workers
Organic chemical synthesizers	Upholstery makers
Plastic foam makers	Wire coating workers
Plasticizer workers	

Toxicology -

Local effects - TDI vapor is highly irritating to eyes, nose and throat, and produces conjunctivitis and coryza-like symptoms. Although TDI liquid is mildly irritating to skin, dermatitis is rare. Continued contact may darken and harden skin.

Systemic effects - Pulmonary irritation, and in some cases pulmonary sensitization, may cause nonproductive cough, wheezing, shortness of breath, and tightness of chest. Diagnoses of bronchitis and bronchial asthma are frequently made.

Medical Surveillance - Preplacement: Medical history, 14" x 17" posterior-anterior chest x-ray, total white blood cell count with differential, pulmonary functions (FVC, FEV_1), and absolute eosinophil count. History should focus on the presence and degree of respiratory symptomatology.
Periodic: Annually as above with the exception of the chest x-ray. Diagnosis of sensitization to isocyanates should exclude the worker from further exposure.

Remarks - *See NIOSH Criteria Document (Appendix D). Persons with a history of respiratory allergy or chronic obstructive pulmonary disease should be counseled that they are at increased risk of adverse health effects from industrial exposure to isocyanates.

References - Bergtholdt, C.P.I.: Recent welding practices at naval facilities. Arch. Environ. Health. 2:257, 1961.
Brugsch, H.G. and Elkins, H.B.: Toluene diisocyanate (TDI) toxicity. New Eng. J. Med. 268:353, 1963. 31 references.
Johnstone, R.T.: Toluene 2,4-diisocyanate; clinical features. Indust. Med. & Surg. 26:33, 1957.
Munn, A.: Experiences with diisocyanates. Trans. Assoc. Indust. Med. Officers. 9:134, 1960.
Wilson, R.H. and Wilson, G.L.: Toxicology of diisocyanates. J. Occup. Med. 1:448, 1959.
Zapp, J.A.: Hazards of isocyanates in polyurethane foam plastic production. A.M.A. Arch. Indust. Health. 15:324, 1957.

Trichloroethylene (ethinyl trichloride, ethylene trichloride, trichloroethene)

TWA - 100 ppm (520 mg/m^3), 200 ppm C
TLV® - 100 ppm (520 mg/m^3)
Uses - Cleaners, degreasers, disinfectants, drugs, dyes, lacquers, paints.
Occupations with potential exposure -

- Anesthetic gas makers
- Cleaners
- Coating makers
- Degreasers
- Disinfectant makers
- Dry cleaners
- Dye makers
- Dyers
- Electronic equipment cleaners
- Electroplaters
- Fumigant workers
- Galvanizers
- Gas purifiers
- Gas workers, illuminating
- Glass cleaners
- Glue workers
- Heat transfer workers
- Lacquerers
- Lacquer makers
- Leather workers
- Mechanics
- Metal burnishers
- Metal cleaners
- Metal polishers
- Metal scourers
- Oil processors
- Optical lens cleaners
- Organic chemical sythesizers
- Painters
- Paint makers
- Paint remover makers
- Petroleum refinery workers
- Photographic plate cleaners
- Polish makers
- Printers
- Resin workers
- Rubber cementers
- Rubber workers
- Shoe workers
- Solvent workers
- Stainers
- Stain makers
- Textile cleaners
- Trichloroethylene workers
- Varnishers
- Varnish makers
- Veterinarians
- Wax makers
- Wool scourers

Toxicology -

Local effects - Liquid or high concentration of vapor may irritate eyes. Repeated contact with liquid or high vapor concentrations can produce a dry, scaly and fissured dermatitis.

Systemic effects - Trichloroethylene has a narcotic effect on central nervous system. In acute intoxications from low concentrations, manifestations include drowsiness, giddiness, dizziness, vertigo, fatigue, headache, exhilaration, nausea, vomiting, and incoordination. A

characteristic symptom is intolerance toward alcohol. High vapor concentrations also have a narcotic effect and can produce unconsciousness, convulsions, coma, and death from respiratory paralysis. Death can occur from primary cardiac failure, ventricular fibrillation, and anoxia secondary to tachypnea and impaired alveolar ventilation. Reported cases of pulmonary edema may have been due to phosgene and hydrochloric acid, which are liberated when trichloroethylene is decomposed by heat.

A great variety of chronic effects have been attributed to trichloroethylene, such as liver damage, neuritis, and neurotic symptoms. Indication of liver damage is usually limited to abnormal liver function tests, but cases of acute yellow atrophy have been reported. The latter may have been due to contaminants or decomposition products. Injury to optic and trigeminal nerves has been reported. Neurotic symptoms are more difficult to evaluate and are doubted by some investigators.

Medical Surveillance - Annual physical examination with special emphasis on cardiac and pulmonary status. If there is any evidence of cardiac arrhythmia, follow up with EKG to confirm and diagnose the arrhythmia. Also, annual SGOT and UA.

Remarks - See NIOSH Criteria Document (Appendix D).

References - See General References (Appendix A).

Trinitrotoluene

TWA - 1.5 mg/m^3, Skin
TLV® - 1.5 mg/m^3
Uses - Explosive.
Occupations with potential exposure -

Demolition workers	Explosive manufacturers
Dye intermediate makers	Photographic chemical makers
Explosive compounders	Trinitrotoluene workers
Explosive loaders	

Toxicology -

Local effects - Contact dermatitis from allergic hypersensitization. May stain skin a light yellow color and discolor hair to a reddish blond.

Systemic effect - Gastrointestinal symptoms often occur first and include nausea, vomiting, and anorexia. Severe liver injury may follow and progress to acute yellow atrophy and death. Oxygen-carrying capacity of the blood is reduced through two mechanisms, namely, red blood corpuscle hemolysis, and formation of methemoglobin. Cyanosis, especially of lips, is a common finding. Breathlessness, weakness, and malaise may be present. Aplastic anemia has been reported to follow exposure to trinitrotoluene.

Medical Surveillance - Quarterly SGOT, LDH, thymol turbidity and hematocrit (or hemoglobin). If exposures are greater than one-third of the TWA, these tests should be accomplished monthly. When evidence of toxicity is found, the employee should be removed from exposure and the monitoring tests repeated weekly until they return to their preexposure value. Weekly monitoring should be continued for 4 weeks after return to a duty involving TNT exposure.

Remarks - Qualitative and quantitative analyses of urine for trinitrotoluene and its metabolites are available. The Webster test can be used to detect trinitrotoluene on skin or in clothing.
Routes of Entry: Inhalation of dust, fume, or vapor. Ingestion of dust or percutaneous absorption from dust.

References - McConnell, W.J.; Flinn, R.H., and Brandt, A.D.: Occupational diseases in government-owned ordnance explosives plants; observations on their prevalence and control during World War II. Occup. Med. 1:551, 1946.

McConnell, W.J. and Flinn, R.H.: Summary of twenty-two trinitrotoluene fatalities in World War II. J. Indust. Hyg. & Toxicol. 28:76, 1946.

von Oettingen, W.F.: Poisoning, A Guide to Clinical Diagnosis and Treatment. 2nd ed. W.B. Saunders Co., Philadelphia, 1958.

Report, USAEHA-OO, Occupational Health Special Study No. 32-093-74, Newport AAP, 1974.

Report, USAEHA-OO, Occupational Health Special Study No. 99-020-74, Letterkenny AD, 1974.

Triorthocresyl Phosphate

TWA - 0.1 mg/m^3
TLV® - 0.1 mg/m^3
Uses - Plasticizer, fuel additive, manufacture of insecticides.
Occupations with potential exposure -

Gasoline additive makers	Polystyrene makers
Gasoline blenders	Polyvinyl chloride makers
Hydraulic fluid workers	Solvent workers
Lead scavenger makers	Surgical instrument sterilizers
Lubricant additive workers	Tricresyl phosphate workers
Nitrocellulose workers	Waterproofing makers
Plasticizer workers	

Toxicology -

Local effects - Contact dermatitis.

Systemic effects - Neurologic effects may be partially caused by inhibition of cholinesterase as well as by demyelination and include polyneuritis and flaccid or spastic paralysis of extremities, usually the lower limbs. Recovery from paralysis may not be complete. There may be nystagmus, dysarthria, and accommodation difficulties.

Medical Surveillance - Annual history and physical with emphasis on the evaluation of the central nervous system.

Remarks - Routes of Entry: Inhalation of vapor or mist; ingestion, percutaneous absorption of liquid.

References - Bidstrup, P.L. and Bonnell, J.A.: Anticholinesterases. Paralysis in man following poisoning by cholinesterase inhibitors. Chem. & Indust. (London). 24:674, 1954. (Abst., A.M.A. Arch. Indust. Health. 11:178, 1955).
Elkins, H.B.: The Chemistry of Industrial Toxicology. 2nd ed. Jchn Wiley & Sons, New York, 1959.
Hunter, D.; Perry, K.M.A., and Evans, R.B.: Toxic polyneuritis arising during the manufacture of tricresyl phosphate. Brit. J. Indust. Med. 1:227, 1944.
Tabershaw, I.R. and Kleinfeld, M.: Manufacture of tricresyl phosphate and other alkyl phenyl phosphates; an industrial hygiene study. 2, Clinical effects of tricresyl phosphate. A.M.A. Arch. Indust. Health. 15:541, 1957.

Turpentine (gum turpentine; oil of turpentine; spirit of turpentine; turps; gum spirit, derived from pine resin; wood turpentine, derived from pine stumps or sulfate wood pulp waste)

TWA - 100 ppm (560 mg/m^3)
TLV® - 100 ppm (560 mg/m^3)
Uses - Pine oil, resins, polishes, paint thinner, paint remover, stains, inks, varnishes, waxes, lacquers.
Occupations with potential exposure -

Belt dressing makers	Resin makers
Furniture polishers	Rubber reclaim workers
Furniture polish makers	Rubber workers
Ink makers	Shoe polish makers
Insecticide makers	Solvent workers
Lacquerers	Stainers
Lacquer makers	Stove polishers
Leather polish makers	Stove polish makers
Lithographers	Turpentine workers
Oil additive makers	Varnish workers
Paint workers	Wax makers

Toxicology -

Local effects - Liquid may produce contact dermatitis from primary irritation as well as allergic hypersensitivity. High concentrations of vapor are irritating to eyes, nose, and throat.

Systemic effects - Headache, anorexia, gastritis, anxiety, excitement, mental confusion, tinnitus, bronchitis, and toxic nephritis.

Medical Surveillance - Annual urinalysis and dermatologic examination.

Remarks - Routes of Entry: Inhalation of vapor; percutaneous absorption of liquid.

References - See General References (Appendix A).

Uranium and Compounds

TWA - soluble compounds, 0.05 mg/m^3
insoluble compounds, 0.25 mg/m^3
TLV® - 0.2 mg/m^2
Uses - Fissionable material, ceramics, glass, photography.
Occupations with potential exposure -

Atomic bomb workers	Uranium hexafluoride makers
Ceramic workers	Uranium millers
Glass makers	Uranium miners
Hydrogen bomb workers	Uranium paint makers
Nuclear reactor workers	Uranium processors
Photographic chemical makers	Uranium workers
Pigment makers	Vanadium millers
Uranium alloy makers	Vanadium miners

Toxicology -

Local effects - Principal skin hazard in handling uranium metal is exposure of hands to beta radiation.

Systemic effects - Uranium and its salts, when absorbed into body, are highly toxic and may cause hepatic degeneration and chronic nephritis. Uranium hexafluoride fumes, when inhaled, may produce a severe chemical pneumonitis. Prolonged inhalation of significant quantities of uranium, its salts, or its decay product, radon gas, may play an important role in causation of lung cancer.

Medical Surveillance - Analysis of urine for uranium annually.

Remarks - Routes of Entry: Inhalation of fume, dust or gas. The following uranium salts are reported to be capable of penetrating intact skin:

Uranyl nitrate	Sodium diuranate
Uranyl fluoride	Ammonium diuranate
Uranium pentachloride	Uranium hexafluoride
Uranium trioxide	

Although uranium and its salts are highly toxic materials, poisoning attributable to their use in industry has not been a serious problem in this country.

References - Elkins, H.B.: The Chemistry of Industrial Toxicology. 2nd ed. John Wiley & Sons, New York, 1959.
Voegtlin, C. and Hodge, H.C.: Pharmacology and Toxicology of Uranium Compounds. McGraw-Hill Book Co., New York, 1949.

Vinyl Chloride (chloroethene)

TWA - 50 ppm (Emergency Temporary Standard)
No detectable level [(analytic method used must have accuracy of 1 ppm ± 50 percent)(proposed permanent standard)]
TLV® - 200 ppm (510 mg/m^3)
Uses - Aerosol propellant, polymerized uses: wire and cable coverings, packaging films, flexible tubing, pipes, bottles, flooring, apparel, automotive parts, home furnishings.
Occupations with potential exposures - Workers in vinyl chloride plants particularly those involved in conversion of the monomer to polyvinyl chloride. Hazard may also exist for those who coat, mold, form, extrude, or otherwise fabricate polyvinyl chloride.

Toxicology -

Local effects - Spills produce severe cooling due to the low boiling point and therefore frost bite is a possibility. Some lung irritation occurs with chronic exposure.

Systemic effects - Central nervous system depression leading to symptoms of dizziness, disorientation, and eventually narcosis. Hepatic toxicity is the major systemic effect. Changes range from increased liver weight, hyperemia, and micropathologic changes to suspected angiosarcomas. A recent study has demonstrated an increased incidence of not only liver but also lung, lymphatic, brain, and urinary tract cancers in vinyl chloride workers.

Medical Surveillance - Medical evaluation will be carried out prior to employment, every 6 months thereafter for those employed greater than 10 years, and annually for all others. Examinations will include a history, a physical exam, and laboratory testing. The history will focus on: alcohol intake; history of hepatitis; past exposures to hepatotoxins; history of blood transfusions; and history of hospitalizations. During the physical examination, specific attention will be paid to detecting an enlargement of the liver and spleen by palpation. Laboratory examinations will include total bilirubin, Alk Phosph, SGOT, SGPT, and GGTP. If one or more of these test results are abnormal, they must be repeated as soon as possible. If these are normal, repeat again in 3 months. If one or more are abnormal, remove the individual from exposure and institute a medical workshop.

Remarks - Since vinyl chloride is a cancer suspect agent, stringent work practices must be instituted to include continuous flow or pressure demand respirators and appropriate protective clothing.

Reference - CFR Part 1910.93q. Vinyl Chloride, Federal Register, Vol. 39, #92, 10 May 1974.

Xylene (xylol, dimethylbenzene)

TWA - 100 ppm (435 mg/m^3)
TLV® - 100 ppm (435 mg/m^3)
Uses - Solvent.
Occupations with potential exposure -

Analytic laboratory workers	Lacquerers
Aviation gasoline workers	Microscopists
Bacteriologists	Painters
Color printers	Pathologists
Dye makers	Pesticide workers
Enamel workers	

Toxicology -

Local effects - Xylene and its concentrated vapor are irritating to eyes, nose, and throat. Repeated contact of liquid with skin will produce a dry, scaly, fissured dermatitis.

Systemic effects - Acute toxicity of inhaled xylene vapor is due to vasodilatory and narcotic effects. Symptoms include flushing of face, headache, fatigue, confusion, paresthesias, dizziness, sleepiness, and unconsciousness. Toxic to liver, heart, kidney, lung and hematopoietic systems.

Medical Surveillance - CBC, SGOT, LDH, and urinalysis annually.

Remarks - Routes of Entry: Inhalation of vapor and, to a small but unimportant extent, percutaneous absorption of liquid.

References - See General References (Appendix A).

Zinc and Compounds

TWA - chloride, 1 mg/m^3
oxide, 5 mg/m^3
TLV® - 1 mg/m^3 (as zinc chloride)
5 mg/m^3 (as zinc oxide)
Uses - Alloys, galvanizing, die casting, cartridge and shell casings.
Occupations with potential exposure -

Alloy makers	Galvanizers
Arc welders	Metal cutters
Brass foundry workers	Metalizers
Braziers	Metal sprayers
Bronze foundry workers	Zinc smelters
Electroplaters	

Toxicology -

Local effects - Zinc chloride is extremely irritating to skin and may produce extensive ulceration; very irritating to eyes, nose and throat. Perforation of nasal septum may be produced. Zinc chromate, zinc cyanide and zinc sulfate may cause dermatitis.

Systemic effects - Inhalation of zinc chloride fumes may produce severe pneumonitis. Certain smoke-screening compounds produce upon ignition essentially zinc chloride and aluminum oxide. When inhaled, the zinc chloride in extremely high concentrations of finely divided particles will produce a chemical irritation of the upper respiratory tract; in the concentrations usually met with among military personnel, an insidious chemical pneumonitis has been reported to occur. When metallic zinc is heated to a temperature near its boiling point, very finely divided zinc oxide fume is produced. Inhalation of freshly formed fumes may produce a brief, self-limiting illness known variously as zinc chills, metal fume fever, brass chills, and brass founder's fever. This condition is characterized by chills, fever, nausea, vomiting, muscular pain, dryness of mouth and throat, headache, fatigue, and weakness. There may also be a slight leukocytosis. These signs and symptoms usually abate in 12 to 24 hours with complete recovery following. Immunity from this condition is rapidly acquired if exposure occurs daily but is quickly lost during holidays or over weekends. Certain other

metallic oxide fumes may cause this condition. These include the oxides of nickel, copper, magnesium, cadmium, iron, mercury, tungsten and titanium.

Medical Surveillance - Annual physical examination of the skin, and upper respiratory tract.

References - Johnson, F.A. and Stonehill, R.B.: Chemical pneumonitis from inhalation of zinc chloride. Dis. Chest. 40:619, 1961.
Morris, G.E.: Toxic hazards; metal fume fever. New. Eng. J. Med. 260:1091, 1959.
Rohrs, L.C.: Metal-fume fever from inhaling zinc oxide. A.M.A. Arch. Indust. Health. 16:42, 1957.

APPENDIX A

GENERAL REFERENCE SOURCES

1. PL 91-596, The Occupational Safety and Health Act (OSHA), 29 December 1970.

2. AR 40-5, Health and Environment, 25 September 1974.

3. AR 40-26, Tuberculosis Detection and Control Program, 30 October 1973.

4. TB MED 81, Cold Injury, 30 March 1970.

5. TB MED 175, The Etiology, Prevention, Diagnosis and Treatment of Adverse Effects of Heat, 25 April 1969.

6. TB MED 236, The Diagnosis and Management of Tuberculosis, 3 February 1972.

7. TB MED 251, Noise and Conservation of Hearing, 7 March 1972.

8. TB MED 269, Carbon Monoxide, 31 May 1968.

9. TB MED 270, Control of Hazards to Health from Microwave Radiation, December 1965.

10. TB MED 279, Control of Hazards to Health from Laser Radiation, 24 February 1969.

11. Federal Personnel Manual, Chapter 339, Qualification Requirements (Medical).

12. Civil Service Handbook X-118, Qualification Standards for Classification Act Positions, July 1966.

13. American Conference of Governmental Industrial Hygienists, Documentation of the Threshold Limit Values for Substances in Workroom Air, 3rd edition, 1971.

14. Patty, Frank A., editor, Industrial Hygiene and Toxicology, Interscience Publishers, Inc., New York, 1963.

15. Sax, N. Irving, Dangerous Properties of Industrial Materials, Van Nostrand Reinhold Company, New York, 1968.

16. US Department of Health, Education and Welfare, Public Health Service, Occupational Diseases, US Government Printing Office, Washington DC, 1966.

17. US Department of Health, Education and Welfare, National Institute for Occupational Safety and Health, Criteria for a Recommended Standard, Occupational Exposures (see Appendix D).

18. Encyclopedia of Occupational Health and Safety, Vols. I (1971) and II (1972), International Labour Office, Geneva.

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APPENDIX B

GLOSSARY OF ABBREVIATIONS

Alk Phosph	Serum alkaline phosphatase
C	Ceiling - Indicates that the TLV or TWA is a ceiling value.
CBC	Complete blood count
CFR	Code of Federal Regulations
EKG	Electrocardiogram
FEV	Forced Expired Volume
FEV_1	Forced Expired Volume in 1 second
FVC	Forced Vital Capacity
GGTP	Gamma Glutamyl Transpeptidase
LDH	Lactic Dehydrogenase
mg/l	Milligrams per liter
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Act
SGOT	Serum Glutamic Oxaloacetic Transaminase
SGPT	Serum Glutamic Pyruvic Transaminase
Skin	Indicates that skin, mucous membrane, and eye exposure must be considered in determining overall exposure to the substance in question.
TLV®	Threshold Limit Value - A copyrighted term of the American Conference of Governmental Industrial Hygienists. Refers to the airborne concentration of substances and represents conditions under which it is believed, by a consensus of experts, that nearly all workers may be repeatedly exposed day after day without adverse effect. They should be used as guides in the control of health hazards and not as fine lines between safe and dangerous concentrations.

TWA	Time Weighted Average - Acceptable levels of chemicals in the air established under OSHA. These levels serve as legal standards.
UA	Urinalysis to include microscopic examination
VC	Vital Capacity

APPENDIX C

URINE SAMPLING

Analyses of urine samples are suggested as medical surveillance for many chemical exposures covered by this guide. Normal and abnormal values are generally given in mg/l. Urine sampling results tend to have a wide variation. Carefully collected 24-hour specimens can reduce this variation, but this is difficult to accomplish. Also, for certain occupational exposures, this is not even desirable. Another method which can reduce variation in test results is to correct urine samples to a standard specific gravity. For industrial exposures, correction to a specific gravity of 1.018 is generally accepted. When using this correction method, a single urine specimen is all that is required. For example, if a urine specimen contains 0.100 mg/l of lead at a specific gravity of 1.018, the value is 0.100 mg/l. If the specific gravity were 1.024, the value would be 0.100 mg/l X $\frac{18}{24}$ = 0.075 mg/l. If the specific gravity were 1.009, the value would be 0.100 mg/l X $\frac{18}{9}$ = 0.200 mg/l. Urine specimens with a specific gravity of 1.005 or less should be disregarded because such urine is too dilute to make an accurate correction and a new specimen should be obtained. Correction to the specific gravity 1.018 is recommended for all urine sampling done for medical surveillance.

APPENDIX D

NIOSH CRITERIA DOCUMENTS

1. Section 20(a)(3) of the Occupational Safety and Health Act of 1970 places upon the Secretary of Health, Education and Welfare the responsibility for the development of "...criteria dealing with toxic materials and harmful physical agents and substances which will describe exposure levels at which no employee will suffer impaired health or functional capacities or diminished life expectancy as a result of his work experience." Such criteria are then transmitted to the Secretary of Labor to assist him in meeting his responsibilities in the issuance of occupational safety and health standards to be enforced by OSHA, the Occupational Safety and Health Administration.

2. The development of criteria documents is a time-consuming, complex task. In recognition of this, to expedite production of the more important ones, NIOSH established a priority list, based in part on the nature and severity of the toxicities, and on the number of persons with potential exposures. Criteria documents published thus far by NIOSH cover the subjects of beryllium, asbestos, noise, cotton, heat stress, carbon monoxide, lead, coke oven emissions, and ultraviolet radiation. Perhaps 15 to 20 others are presently in varying stages of completion. It is the NIOSH plan, we understand, to accelerate production to approximately 40 documents per year.

3. An important feature of the documents is the extensive documentation required throughout. With very few exceptions, virtually every statement in the documents must be based on published literature. Among the major topics covered are the following: data on the chemical and physical properties of the elements and compounds involved, their sources, where occupational exposures occur, environmental data on the severity of such exposures, a history of occupational exposures, sampling and analytical methods for measuring exposures, both of the workroom air and of biological specimens, engineering control methods, recommended work practices, and a thorough consideration of the biological effects of exposure, discussion of the effects on humans, epidemiological studies, animal toxicity, and correlation of exposure and effects. This is followed by a review of previous and existing standards, both foreign and domestic, and a discussion of the basis for environmental and biological standards now recommended by NIOSH. In the document there is a recommended occupational exposure standard usually containing eight sections as follows:

a. Maximum 8-hour time-weighted-average concentration and ceiling concentration permitted, as measured by specified sampling and analytical procedures described in detail in the appendices.

b. Medical/biological requirements, including physical examinations, and examinations of biological specimens as specified.

c. Warning information to be included on labels of containers handled by workers and on signs posted in work areas.

d. Requirements for types and use of personal protective equipment, including eye protection, respiratory protection and protective clothing.

e. Requirements regarding the education of employees of the health hazards associated with their jobs.

f. Specific work practices to minimize exposures.

g. Sanitation requirements.

h. Specific details of monitoring to be performed, including the frequency of sampling, and the minimum period that records of sampling must be retained.

4. These documents are not legal standards. They are used by the Secretary of Labor to develop standards (TWA).

The following NIOSH documents can be obtained from the Superintendent of Documents and from the National Technical Information Service:

Recommendations for Occ. Exposure to:	GPO Stock No:	Price	NTIS No.	Price	NTIS Microfiche Price
Asbestos	1733 00009	$2.10	PB209 510	$3.00	$2.25
Beryllium	1733 00011	$2.10	PB210 806	$3.00	$2.25
Hot Environments	1733 00010	$1.25	PB210 794	$5.45	$2.25
Carbon Monoxide	1733 00006	$2.00	PB212 629	$3.00	$2.25
Noise	1733 00007	$2.00	PB213 463	$3.00	$2.25
Ultraviolet Radiation	1733 00012	$1.25	PB214 268	$5.45	$2.25
Inorganic Lead	1733 00013	$1.25	PB214 265	$5.45	$2.25
Coke Oven Emissions	1733 00014	$0.95	PB216 167	$4.50	$2.25
Chromic Acid	1733 00020	$1.10	PB222 221	$4.85	$2.25
Trichloroethylene	1733 00023	$1.30	PB222 222	$5.45	$2.25
Inorganic Mercury	1733 00022	$1.50	PB222 223	$5.45	$2.25
Toluene	1733 00019	$1.25	PB222 219	$5.45	$2.25
Toluene Diisocyanate	1733 00021	$1.25	PB222 220	$5.45	$2.25
Inorganic Arsenic	1733 00030	$1.50	PB228 151	$4.50	$2.25
Sulfur Dioxide	1733 00029	$1.55	PB228 152	$4.50	$2.25
Toxic Substances List - 1973 Edition -	1733 00016	$7.90			

Send orders to: Superintendent of Documents
Government Printing Office
Washington, D.C. 20402

or: National Technical Information Service
5285 Port Royal Road
Springfield, VA 22151

APPENDIX E

EXAMINATIONS FOR VARIOUS IONIZING RADIATION SOURCES

TABLE

Category of Radiation Worker	Exposure	Personnel Monitoring
Nuclear reactor personnel	Gamma rays, fission products, neutrons, beta rays while changing fuel elements.	Annual whole body counting when available, urine bioassay for uranium, gross beta urine bioassay and thyroid uptake scan without giving any I-131 or Technesium 99m semiannually. Film badge program.
Linear reactor personnel	Electron or particle beam, x-rays.	Film badge program.
	Uranium targets	Urine bioassay for uranium semiannually.
	Tritium targets	Urine bioassay for tritium taken 4 hours after changing targets.
Self-luminous dial workers	Radium (see TB MED 232)	Film badge program, radon breath sample semiannually.
	Tritium	Urine bioassay for tritium monthly.
Neutron generator workers	Changing tritium targets	Film badge program, urine bioassay for tritium taken 4 hours after changing target.
Medical, dental, and industrial x-ray technicians or users	X-rays	Film badge program.
Radiation therapy workers	Radium or cesium needle implants, cobalt-60 sources, high power x-rays, etc.	Film badge program.
Medical isotope workers	Iodine-131 or Technesium 99m.	Film badge program, annual or periodic thyroid uptake scan without giving any iodine-131 or Technesium 99m.
	All others	Film badge program.
Research workers	Alpha emittors (examples: plutonium, polonium & uranium)	Urine bioassay for gross alpha activity - semiannually.
	Beta emittors (examples: tritium, carbon-14, phosphorus-32, strontium-90)	Urine bioassay for gross beta activity - semiannually.
	Gamma emittors (examples: silver-110, cobalt-60, cadmium-109, iodine-131, radium)	Film badge program, urine bioassay for gamma activity - semiannually.
	Tritium	Urine bioassay for tritium monthly if exposure warrants, otherwise semiannually.
	Uranium	Urine bioassay for uranium - semiannually.
Uranium milling workers	Uranium	Urine bioassay for uranium - semiannually.

APPENDIX E

EXAMINATIONS FOR VARIOUS
IONIZING RADIATION SOURCES

TABLE

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Nuclear reactor personnel	Gamma rays, fission products, neutrons, beta rays while changing fuel elements.	Annual whole body counting when available, urine bioassay for uranium, gross beta urine bioassay and thyroid uptake scan without giving any I-131 or Technesium 99m semiannually. Film badge program.
Linear reactor personnel	Electron or particle beam, x-rays.	Film badge program.
	Uranium targets	Urine bioassay for uranium semiannually.
	Tritium targets	Urine bioassay for tritium taken 4 hours after changing targets.
Self-luminous dial workers	Radium (see TB MED 232)	Film badge program, radon breath sample semiannually.
	Tritium	Urine bioassay for tritium monthly.
Neutron generator workers	Changing tritium targets	Film badge program, urine bioassay for tritium taken 4 hours after changing target.
Medical, dental, and industrial x-ray technicians or users	X-rays	Film badge program.
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	All others	Film badge program.
Research workers	Alpha emittors (examples: plutonium, polonium & uranium)	Urine bioassay for gross alpha activity - semiannually.
	Beta emittors (examples: tritium, carbon-14, phosphorus-32, strontium-90)	Urine bioassay for gross beta activity - semiannually.
	Gamma emittors (examples: silver-110, cobalt-60, cadmium-109, iodine-131, radium)	Film badge program, urine bioassay for gamma activity - semiannually.
	Tritium	Urine bioassay for tritium monthly if exposure warrants, otherwise semiannually.
	Uranium	Urine bioassay for uranium - semiannually.
Uranium milling workers	Uranium	Urine bioassay for uranium - semiannually.

APPENDIX F

SELECTED LIST OF KNOWN AND SUSPECTED INDUSTRIAL CARCINOGENS

Substance	Industrial Uses	Tumor Site (animal or man)
I. Aromatic Amines		
1. 2-Acetylaminofluorene*	Cancer Research	bladder, liver
2. 4-Aminodiphenyl*	Cancer Research Chemical Analysis Explosives Production Dye Manufacturing	bladder, intestine
3. Benzidene (and salts)*	Dye Manufacturing Rubber Compounds Manufacturing Medical Lab Testing Chemical Lab Reagent Plastics Production Printing Ink Production Linoleum and Floor Tile Production	bladder
4. 3,3'-Dichlorobenzidine* (and salts)	Pigment Production Textile Production Plastic Manufacturing	bladder, liver, small intestine
5. 4-Dimethylaminoazobenzene	Chemical Analysis	liver
6. Alpha-Naphthylamine*	Dye Manufacturing Pesticide Manufacturing Photographic Chemical Production Antioxidant in Synthetic Lubricants	bladder
7. Beta-Naphthylamine*	Dye Production	bladder
8. 4-Nitrobiphenyl*	Plastics Production Rubber Production Dye Intermediate	bladder
9. N-Nitrosodimethylamine*	Rubber Manufacturing Textile Production Solvent for Plastic Rocket Fuel Production Antioxidant Copolymer Treatment Additive to Lubricants Medical Treatment	liver, kidney, lung
10. Beta-Propiolactone*	Acrylate Manufacturing Photographic Dye Manufacturing Disinfectant Acid Production	skin, liver
11. Bis-chloromethylether*	Textile Production Polymer Fabrication Production of Ion Exchange Resins	skin, lung, nose
12. Methyl Chloromethyl* Ether	Ion Exchange Resin Manufacture Drug Industry	skin, lung, nose
13. 4,4'-Methylene(bis)* 2-Chloroaniline	Urethane Foam Manufacturing	lung, liver, bladder
14. Ethyleneimine*	Mine Water Clarifier Paper Making Chemical Production Veterinary Medicine	lung, liver, bladder

Substances	Tumor Site (animal or man)
II. Polycyclic Aromatic Hydrocarbon Mixtures	
15. Coal tar and pitch	skin, scrotum, larynx, lung
16. Petroleum asphalt, bitumen, tar coke, pitch, carbon (lignite tar, shale oil tar, synthetic hydrogenated coal, berguis oil tars)	skin, scrotum
17. Paraffin and petroleum waxes	skin
18. Soot, carbon black	skin, scrotum, lung
19. Anthracene oil	skin, scrotum
20. Creosote	skin
21. Mineral oils (petroleum, shale and lignite oils, greases, solvents, cutting oils)	skin, scrotum
III. Miscellaneous Organic Exposures	
22. Isopropyl oil	paranasal sinus, larynx, lung
23. Mustard gas	paranasal sinus, larynx, lung
24. Benzanthrone	lung (?), kidney (?)
IV. Inorganic Chemicals	
25. Arsenic compounds	skin, lung, liver
26. Asbestos	lung, pleura, peritoneum
27. Chromates	lung
28. Nickel carbonyl	nasal sinus, lung
V. Radiation	
29. Ultraviolet solar	skin
30. X-ray radiation	skin, bone
31. Alpha, beta and gamma radiation	lung, liver, larynx, thyroid, subcutaneous and hematopoietic tissue, kidney

* Carcinogen listed in Federal Register, 29 January 1974.

Exposure Limits - Where substances have a specific TLV® or TWA (e.g., arsenic, asbestos), these limits are applicable. Those substances (starred) covered by 29 CFR 1910.93 have much more stringent limits. All those substances containing 1 percent, by weight or volume, of a known animal carcinogen or 0.1 percent of a known human carcinogen must be utilized only in isolated or closed systems. Rigorous work practices are also required. (Specifics should be checked in the reference.)

Medical Surveillance - See specific substance (if discussed separately). In general, preplacement and annual cytological evaluation, by the Papanicolaou technique, of the pertinent body fluid, if readily accessible, is the examination of choice (e.g., sputum cytology for pulmonary carcinogens, urine cytology for bladder and kidney carcinogens). Liver carcinogen exposures may be evaluated by use of a liver battery (see medical surveillance of vinyl chloride workers). The larynx, skin, nose, and scrotum may be evaluated by the pertinent physical examination.

Reference - 29 CFR 1910.93, Federal Register, Vol. 39, No. 20, 29 January 1974.